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ABSTRACT

This study investigated the effect of two external conditions on the learning of principles by children. The external conditions were instruction on the major concepts related in the principle and the number of teaching examples and teaching nonexamples of the principle presented with a statement of the principle. Subjects were 159 fifth-grade students of average ability and socioeconomic status. The principles were presented in self-instructional lesson booklets, where the instructional variables of interest were systematically varied. Variations in the type of lessons read by the subjects constituted the experimental conditions. Mastery of the principles was determined by tests designed to assess subjects' knowledge of, and ability to apply, the principles. Results indicated that a rationally selected set of examples and nonexamples was more facilitative than one example, although it was concluded that, for easy principles, providing one example was equally effective as a rationally selected set when instruction on concepts related in the principle was also provided. Main effects for instruction on concepts related in the principles were not found to be significant. The conditions associated with this unanticipated result were discussed. Extensive appendices are included. (Author/PC)

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TECHNICAL REPORT NO. 309
(Part 1 of 2 Parts)

instructional factors relating to children's principle learning

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Technical Report No. 309 (Part 1 of 2 Parts)

INSTRUCTIONAL FACTORS RELATING TO CHILDREN'S PRINCIPLE LEARNING

by Katherine Vorwerk Feldman

Report from the Project on Conditions of School Learning and Instructional Strategies

Herbert J. Klausmeier
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Wisconsin Research and Development
Center for Cognitive Learning
The University of Wisconsin

August 1974

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ABSTRACT

The present study investigated the effect of two external conditions on the learning of principles by children. The external conditions were instruction on the major concepts related in the principle and the number of teaching examples (correct applications) and teaching nonexamples (incorrect applications) of the principle presented with a statement of the principle.

Subjects were 159 fifth-grade students of average ability and socioeconomic status. Two principles from each of two subject matters (mathematics and language arts) served as the content of the learning task. One principle from each subject matter was designated as "easy" and one as "difficult" on the basis of previous research.

The principles were presented in printed, self-instructional lesson booklets. Several versions of the booklets were prepared in which the instructional variables of interest were systematically varied. Variations in the type of lessons read by the subjects constituted the experimental conditions. Mastery of the principles was determined by tests designed to assess subjects' knowledge of and ability to apply the principles.

In general a rationally selected set of examples and nonexamples was found to be more facilitative than one example, although it was concluded that for easy principles providing one example was equally effective as a rationally selected set when instruction on concepts related in the principle was also provided. Main effects for instruction on concepts related in the principles were not found to be significant; the conditions associated with this unanticipated result were discussed.

Chapter I

INTRODUCTION

Conceptual learning and development has become a topic of increasing interest to both psychologists and educators in recent years. A large and growing body of literature in the area comprising a variety of theoretical viewpoints and empirical investigations currently exists. Additionally, several practical applications of existing knowledge to the classroom teaching situation have been proposed (Klausmeier & Feldman, 1974; Klausmeier, Ghatala, & Frayer, 1974; Markle & Tiemann, 1969, 1972; Tennyson, Woolley, & Merrill, 1972).

The great majority of the literature on concept learning, however, deals with the acquisition of discrete, isolated concepts. While many concepts may indeed be learned in isolation, particularly during the early years of life, most concepts taught in schools and acquired by adults are learned within the context of generalized subject matter areas which consist of sets of related concepts. How related concepts, or more accurately the relationships between or among concepts, are learned and can most effectively be taught is thus a topic of some importance.

Two general types of relationships between or among concepts have been described in the literature. The first is that found in taxonomic conceptual systems involving supraordinate and subordinate classes. The

second includes any statement of relationship between two or more concepts which is used to define a more inclusive concept or express a composite idea. Statements expressing composite ideas are commonly called such things as principles, rules, axioms, or laws. The present study deals with how relationships of this second type are learned.

The research reported in this dissertation is part of an ongoing research project focusing on concept learning being carried out at the Wisconsin Research and Development Center for Cognitive Learning. The project is designed to increase knowledge about stimulus variables and cognitive operations related to concept attainment both in the laboratory and in the classroom. One of the major results of this research program is the Model of Concept Learning and Development (CLD) which has been presented in detail by Klausmeier, Ghatala, and Frayer (1974). The CLD model was conceived of as a framework upon which to base further research and instructional design, and as such it has served as a guide and impetus for a variety of empirical investigations including the present study.

In the CLD model concept learning is treated as a complex form of learning that can be subdivided into four hierarchical levels. These levels represent levels in attainment of the same concept and can be distinguished from each other on the basis of the cognitive operations involved in the attainment of each one. Internal and external conditions of learning related to the specified levels and the possible uses and extensions of attained concepts are also described in the model.

The four levels of concept attainment specified in the CLD model are concrete, identity, classificatory, and formal. Each level represents knowledge about a particular concept at a higher level of

inclusiveness and abstractness. Attainment at the concrete level is inferred when the learner cognizes an object that he or she has encountered previously. Attainment at the identity level is inferred when the learner recognizes the previously encountered object even when seen from another perspective or sensed in a different modality. Attainment at the classificatory level is inferred when the learner is able to identify at least two different examples of a concept as belonging to the same set or class, even though he or she may not be able to name the attribute(s) common to them. Finally, attainment at the formal level is inferred when the learner can name the concept and each of its defining attributes, correctly classify examples and non-examples, and describe the basis of the classification in terms of the defining attributes.

A concept attained only at the concrete or identity levels may be used in solving simple, perceptually based problems. However, once a concept has been learned at the classificatory or formal levels it may be used to cognize relations among the concept and other concepts, either subordinate-supraordinate or principle relationships, and also to solve sophisticated problems.

The present study is concerned with the use of concepts in principle relationships. Specifically, the study focuses upon two instructional variables that are hypothesized to affect principle learning. The first is instruction on each of the main concepts that are related in the principle. That this is potentially an important variable in principle teaching follows directly from the CLD model and also from the work of Gagné (1970) and Ausubel and Robinson (1969). The second variable is the number of teaching examples (correct applications) and teaching

nonexamples (incorrect applications) that are presented with a statement of the principle. Previous research (Gagné and Wiegand, 1968) has shown that very "simple" or "easy" principles can be mastered from a statement of the principle and one example. However, there is some indication that a single example is insufficient when "complex" or "difficult" principles are being learned (Anderson, 1973). In the present study the use of a "rational set" of examples and nonexamples (Markle and Tiemann, 1969) was extended from concept teaching to the teaching of principles. It was expected that the presentation of a rationally selected set of teaching examples and nonexamples of a principle would result in significantly greater mastery of difficult principles than would result from the presentation of a single example.

Method

Subjects were 159 fifth-grade students who studied a series of two printed lessons. Several versions of the lessons were prepared in which the instructional variables of interest were systematically varied. Variations in the type of lessons presented to the subjects constituted the experimental conditions.

Two principles from each of two subject matters (mathematics and language arts) served as the content of the learning task. One principle from each subject matter was selected to be either "easy" or "difficult" on the basis of previous empirical results.

Subjects read the two lessons during the same experimental session. After completion of the lessons, subjects were given a test which assessed their knowledge of and ability to apply the principles. The entire session of two lessons and the test administration lasted between 45 minutes and one hour.

Two analyses of covariance and appropriate post hoc comparisons were used to analyze the data. The covariate was a reading achievement score drawn from a standardized test. One analysis of covariance was carried out on the total scores on the knowledge items while the other analysis of covariance was carried out on the total scores on the application items.

Purpose and Hypotheses of the Study

The purpose of the present study was to investigate the effects of several instructional conditions on principle learning. The following specific results were hypothesized:

(1) Easy principles would be mastered more fully then difficult principles.

(2) Subjects instructed on the separate concepts contained in the principles would perform significantly better than subjects not receiving such instruction.

(3) Subjects given a statement of the principle and either a rationally selected set of examples and nonexamples or one example would perform significantly better than control subjects who did not receive a statement of the principle or any illustrative instances.

(4) (a) For a difficult principle a rationally selected set of examples and nonexamples would be more facilitative than one example regardless of whether subjects had received instruction on the concepts or not.

(b) For a simple principle a rationally selected set of examples and nonexamples would be equally effective as one example if subjects had received instruction on the concepts

contained in the principle. However, if subjects had not received instruction on the target concepts, a rationally selected set would be more facilitative than one example.

Significance of the Study

Gagné has stated that principles "are probably the major organizing factor, and quite possibly the primary one, in intellectual functioning" (1970, p. 190-191). Yet very little is known about how these important factors are learned. Knowledge of the effect of the instructional variables studied in this experiment thus could have important implications for the theory of principle learning.

The present study also has potential significance for teachers and other curriculum developers concerned with the external conditions of principle learning in classroom settings. The results of this study and other similar studies dealing with the effect of instructional variables on principle learning could form the basis for a set of guidelines for effective teaching of principles. Such a set of guidelines could be a valuable advance in the theory of instructional design.

Chapter II

REVIEW OF RELATED LITERATURE

The Nature of Principles

A principle is a relationship among two or more concepts. Typically principles define a more comprehensive concept, express a composite idea, or explain a procedure. A broad range of phenomena from many disciplines may be described in this way: rules that pertain to language, mathematical statements, scientific principles, and so on.

The external representation of a principle is a verbal statement. However, the principle is not the verbal statement; it is the "idea" expressed in the statement. A learned rule is what Gagné (1970) calls an "internal state" of the individual, "an inferred capability that enables the individual to respond to a class of stimulus situations with a class of performances" (p. 191). The learner may even acquire a particular principle without being able to verbalize a statement of it. Gagné's example clarifies these issues:

> The individual responds to a class of stimulus situations (2 + 3, 3 + 4, 7 + 5, and so on) with a class of performances (3 + 2, 4 + 3, 5 + 7, and so on) that are predictably related to the stimuli of a relation that may be expressed as "independence of order." The rule that governs this behavior may be represented by the statement, "adding the class of numbers a to the class of numbers b is independent of the order in which a and b are combined." It may be noted that we as external observers may represent the rule by this verbal statement. In fact, we must represent it in some way if we are going to talk about it. However, we do not know how the individual being observed would represent the rule, and at this point we are not concerned with that question. What is observed is that the individual responds

> regularly to a large class of specific situations; in other words, he applies a rule [pp. 191-192].

An individual's understanding of a principle may differ from the meaning of that principle generally accepted by his or her society. Thus, principles function both as mental constructs of individuals and as publicly defined entities (Klausmeier, Ghatala, & Frayer, 1974). It is, of course, the publicly defined meaning of a principle that is taught in the classroom and presented in reference texts.

Klausmeier and Goodwin (in press) have identified six dimensions along which all principles vary. The authors consider these to be the defining attributes of the term principle. These dimensions are: learnability, the ease with which a principle can be learned; usability, the usefulness or range of applications of a principle in reasoning or understanding new phenomena; validity, the extent to which experts agree on the meaning of a principle; generality, the degree to which a principle subsumes other (subordinate) principles and concepts; power, the extent to which a principle facilitates or is essential to the learning of other principles; and structure, the nature of the relationship of the concepts contained in the principle.

Once an individual has learned a principle he or she begins to exhibit principle-governed behavior. That is, in Gagné's (1974) words, the individual begins to respond to entire classes of stimuli with classes of responses. For example, the individual who has learned the rule of "independence of order" will be able to apply that rule to any combination of numbers in any order regardless of whether the situation is novel or one with which the learner is familiar.

Learning a principle also provides the individual with a basis for understanding and relating new phenomena, predicting consequences, and

solving principle-related questions (Klausmeier, Ghatala, & Frayer, 1974). The principle becomes a tool for reasoning in these situations. Thus, "if one has the concepts of desert, irrigation, and alfalfa and if one also understands various relationships among nutrients, water, and alfalfa, one can predict that alfalfa will grow in a desert region when water and certain nutrients are supplied under proper conditions" (Klausmeier, Ghatala, & Frayer, p. 169). Obviously, the more usable and powerful a principle is to an individual the more valuable it is as a cognitive tool.

Summary. A principle is a relationship among two or more concepts. While principles are generally represented by verbal statements, it is the idea expressed by the relationship and not the verbal statement which actually constitutes the principle. Principles vary among each other along six dimensions. These dimensions are learnability, usability, validity, generality, power, and structure. After a principle has been learned the individual is able to apply the principle to novel situations and also to use the principle as a cognitive tool for reasoning and understanding.

Classifying Principles

As was pointed out in the previous section, a great variety of phenomena from disciplines as disparate as religion and sports are called principles. This diversity makes a meaningful classification of principles across subject matters difficult to derive. Only two classification schemes have been proposed, both of which are based in a general sense upon the structure of the principle. The first has been proposed by Klausmeier, Ghatala, and Frayer (1974) and the second by Gagné (1970).

Klausmeier, Ghatala, and Frayer suggest that principles can be classified on the basis of the general type of relationship that they express. Four classes or types of principles are defined in this way by the authors. These types are causal, probabilistic, correlational, and axiomatic. The first three imply specific relationships. Causal principles express a cause and effect relationship and can be stated in an "if-then" form. Probabilistic principles express the probability of a particular event occurring and permit actuarial prediction. Correlational principles express the likelihood of the joint occurrence of two or more events. The fourth classification, axiomatic, does not imply a particular relationship. Axiomatic principles are defined simply as principles that are stated as "givens" in the form of generally accepted axioms. The specific relationship expressed by an axiomatic principle may thus be anything other than causal, probabilistic, or correlational.

Klausmeier, et al., include a variety of examples to illustrate their classification schema. A few of these examples follow:

Causal: Tuberculosis is caused by the organism myobacterium tuberculosis.

Probabilistic: The probability of getting a head on any one toss of a coin is .50, given that the coin is fair.

Correlational: Sample correlations between two sets of scores on standardized reading achievement tests of the same children taken at yearly intervals during the successive elementary-school years range from .70 to .90.

Axiomatic: Nouns can be classified according to their use in a sentence; nouns are frequently used as the subject of a sentence or as the direct or indirect object of a verb.

Undoubtedly, the majority of principles taught in the classroom fall into the axiomatic classification. Bernard (1974) has identified

several subclasses of the category which lend support to this idea. These subclasses are what he calls fundamentals, laws, rules, theorems, and axioms.

Fundamentals are principles which are essential to the basic structure of a discipline or philosophy. Such statements as "mechanization is the secret to America's greatness" or "all men are created equal" would be classified as fundamentals. Laws are either scientific laws stating relationships among physical phenomena such as "enthalpy is the internal energy of a system plus the product of the pressure and volume of the system," or societal laws which dictate conduct. Rules are primarily principles related to language arts, for example, rules of punctuation. However, the term also can be applied to informal, personal statements of behavioral expectation such as "wash [your] hands before coming to the table." The terms theorems and axioms refer primarily to mathematical statements, although axioms also can be used in reference to what most people regard as "common sense" truths, for example, "nothing is as dead as yesterday's newspaper."

Gagné's (1970) classification system is less sophisticated than that developed by Klausmeier, Ghatala, and Frayer (1974), but in some ways it is a more useful framework within which to consider how principles can be taught most effectively. However, the two are not mutually exclusive, and Gagné's schema can be seen easily as a further way of classifying each of the four types of principles Klausmeier et al. describe.

Gagné distinguishes between what he calls "simple" and "complex" principles (rules in Gagné's terminology). The distinction is in part simply a structural one. The more complex a principle the greater the

number of concepts of which it is composed. The structurally simplest principles relate only two concepts in an "if A then B form." The more complex principles may even relate two or more simpler rules in addition to a large number of concepts.

Complexity is also defined by Gagné in terms of abstractness. Complex rules involve subtle discriminations and abstract concepts (presumably concepts for which there are few readily perceptible instances in the environment). Simple rules do not involve subtle discriminations and relate concepts that are not considered abstract. The simplest rules, according to Gagné, are the ones which the young child learns.

Examples of what Gagné calls a simple and a complex rule which show the dual combination of formal structure and abstractness to the determination of complexity are the following:

Simple rule: Round things roll.

Complex rule: Metamorphosis occurs when the larva of an insect turns into a pupa.

While the number of concepts (or simpler rules) of which a principle is composed is an objective and easily applied measure of complexity, abstractness is not. The degree of abstractness of a rule or concept must depend upon the particular society one focuses on, a particular individual's experiences within that society, and a good deal of subjective judgment. While a lawyer might consider the term "enthalpy" highly abstract and difficult to understand, a physical chemist would not. Without an operational way of defining abstract or complex Gagné's schema becomes less useful than it potentially could be.

Summary. A great variety of statements are called principles. Two general schemes have been proposed for classifying these statements. The first, suggested by Klausmeier, Ghatala, and Frayer (1974), categorizes

principles on the basis of the type of relationship that they express. Four types of relationships are mentioned: causal, probabilistic, correlational, and axiomatic. The second, suggested by Gagné, classifies principles in terms of complexity. The more complex a principle the greater the number of concepts it relates and the more abstract those concepts are.

The Learning of Principles

Being able to recite the statement of a principle does not imply that the principle has been learned. The statement of a principle can be rotely memorized without the principle itself being attained. Rather, learning of a principle implies that the idea expressed by the principle has been meaningfully understood and that it can be applied or demonstrated.

Ausubel (1963, 1968) and Ausubel and Robinson (1969) have described internal mechanisms and prerequisite conditions that underlie the meaningful learning of principles, or "propositions" in their terminology. The major prerequisite condition is that the proposition must be relatable to existing facts, concepts, propositions, theories, and raw perceptual data in what Ausubel and Robinson call the learners' existing "cognitive structure." If the new material is relatable in this way, and the learner is motivated to do so, the proposition will become meaningfully incorporated into his or her cognitive structure and hence learned.

There are three general types of relationships that can hold between newly acquired propositions and the learner's cognitive structure according to Ausubel and Robinson. The first kind of relationship is a subordinate one. This is the most common relationship existing between new material and established ideas. When a subordinate relationship is

formed, the new proposition becomes subsumed under existing and more inclusive ideas in cognitive structure. There are in turn two kinds of subsumption, defined by the type of material being incorporated. In derivative subsumption the new proposition is merely an illustration of an already established, more inclusive proposition, or can be derived from an existing proposition. In correlative subsumption, however, the new material elaborates, extends, modifies, or qualifies previously learned ideas. For example, if an individual has learned the concept parallelogram and then learns the proposition "the opposite sides of a parallelogram are equal in length" by relating the proposition to his or her understanding of what a parallelogram is, the individual's concept of parallelogram will be modified and extended.

The second type of relationship that can hold between new material and the learner's cognitive structure is a supraordinate one. The new material which is incorporated stands in a more inclusive relationship to existing ideas and, once learned, subsumes those ideas. The supraordinate proposition may be developed inductively from existing subordinate material or it may be simply presented to the learner. This latter approach, Ausubel and Robinson point out, is the method typically used by teachers and textbook writers. General and inclusive material is presented first followed by more particular and subordinate ideas.

The third and final type of relationship, combinatorial, results when a new proposition bears neither a subordinate nor a supraordinate relationship to existing cognitive structure but does consist of a combination of previously established ideas that can be related to a broad background of material in the learner's cognitive content. Ausubel cites as examples literary metaphors and scientific models. He

suggests, for instance, that to explain the derivation of the period of a pendulum one might point out to students well versed in both geometry and Newtonian mechanics that the pendulum can be considered structurally equivalent to a line segment and a Newtonian particle. Known principles relating to geometry and the movement of Newtonian particles can then be used to explain the formula for the period of a pendulum.

Gagné (1970), like Ausubel and Robinson, also argues that principles must be relatable to previously learned material if they are to be meaningfully attained. However, he makes his point somewhat more precisely by stating that it is the concepts related by the principle which must have been learned previously for the principle itself to be meaningfully incorporated.

The idea that learning subordinate concepts is an essential prerequisite to principle attainment follows directly from Gagné's description of what he feels are the eight basic types of learning. These are signal learning, stimulus-response learning, chaining, verbal association, discrimination learning, concept learning, rule (principle) learning, and problem solving (Gagné, 1970).

According to Gagné the eight types of learning are distinguishable from each other in terms of the conditions necessary for their occurrence, and each one involves a different internal capability on the part of the learner. The internal capabilities, and hence the corresponding learning types, are hierarchical and cumulative. With one exception (signal learning is not a prerequisite for stimulus-response learning), each capability is a prerequisite for the next higher-order capability. Thus, concept learning becomes a prerequisite for rule learning, which is in turn a prerequisite of problem solving.

The model of concept learning and development (CLD) proposed by Klausmeier, Ghatala, and Frayer (1974) likewise indicates that individual concepts must be learned before any statement of relationship among those concepts can be understood and used. Moreover, in a cross-sectional study (Klausmeier, Sipple, & Allen, 1974a,b) designed to validate the model direct support for this central idea was demonstrated.

Briefly to reiterate (see Introduction), the core of the CLD model consists of four successively higher levels at which concepts may be attained. Each successive level represents knowledge about concepts at a higher degree of inclusiveness and abstractness. The levels are concrete, identity, classificatory, and formal.

The cross-sectional study carried out to supply external validity for the model involved about 800 students from four grade levels (kindergarten, third, sixth, and ninth grade). Students participating in the study were drawn from the public school population of two suburban Wisconsin communities and they were judged to be typical of students from similar communities throughout the state. Principles were selected from three substantive areas and they were in general axiomatic. Understanding of the major or key concept in each principle as well as knowledge of the principle itself were tested. A typical principle, with major concept underlined, is the following: All <u>equilateral triangles</u> are similar in shape.

Based on the results of the research the authors showed that not until the major concept contained in a principle was attained at the classificatory level were even small proportions of students able to answer questions correctly that tested their knowledge of and ability to apply the principle. Two conclusions can be drawn from this finding.

First, at least the major concept (or concepts) of a principle must be familiar to the learner if the principle is to be meaningfully learned. Second, the key concept(s) must have been attained at least at the classificatory level and preferably at the formal.

In addition to stating that the concepts related in a principle must be known to the learner, Gagné (1970) has also specified several conditions within the learning situation which must be met for principle learning to take place. The first type of condition Gagné calls an internal condition of the learner. Conditions related to the learning situation he refers to as external conditions. External conditions are essentially instructional variables.

The external conditions which Gagné sees as important in principle learning, presented in sequential order, are the following:

(1) The general nature of the desired terminal performance in most cases whould be stated. This serves a dual purpose. It insures that the learner will know when he or she has finished learning, and it provides the learner with a means of obtaining immediate reinforcement for the desired terminal act. The principle itself is not stated; only the kind of performance that will demonstrate its attainment. For example, an instructor teaching the principle "round things roll" might begin instruction by saying, "I want you to answer the question, 'What kinds of things roll?'."

(2) The learner should be encouraged to recall relevant concepts related in the principle.

(3) Verbal cues for the principle as a whole are given, which, depending on length, may be an exact verbalization of the principle. If the principle is very complex it may be necessary to break it into simpler parts and present each part separately.

(4) The learner is asked to demonstrate one or more concrete instances of the principle and is given appropriate feedback and reinforcement.

(5) (Optional) The learner is asked to state the principle. This condition is included only so that the learner will be able to discuss the principle using complete and accurate terminology at some later date. Gagné makes clear that it is not an essential part of principle learning itself.

The importance of providing, with a statement of the principle, labeled examples (correct applications) and possibly nonexamples (misapplications) for the learner to study is not discussed by Gagné. However, he does suggest that when the concepts related in a principle have been thoroughly learned the principle itself can be attained from its statement alone and on a single occasion. Gagné (1970) points out that for adults (and presumably many older children) the external conditions of principle learning are often reduced to printed statements of the principles in textbooks. If the concepts related in the principle have been well-learned, Gagné argues, "one may suppose that the adult who has the intention to do so can learn the new rule entirely from the verbal statement itself" (Gagné, 1970, p. 197).

Summary. A principle is said to be learned when the idea expressed by the principle is meaningfully understood and can be applied or demonstrated. Internal and/or external conditions of principle learning have been described by Ausubel and Robinson (1969), Gagné (1970), and Klausmeier, Ghatala, and Frayer (1974). The major internal condition, which is supported by empirical evidence, is that the concepts that are related in the principle must be attained (at least at the classifi-

catory level) before the principle can be meaningfully incorporated. External conditions refer to the learning situation and are essentially instructional variables. If the major internal condition has been fulfilled, Gagné suggests, the necessary external conditions reduce to a statement of the principle.

Developmental Considerations

Very young children have difficulty understanding relational structures (Flavell, 1970). For example, expressions such as "brother of," "darker," and "middle-sized" are taken to be names for objects sharing common properties instead of relations between objects. A young child taught which of two gray objects is the darker may continue to select that object as the darker one even when placed next to a black object because the adjective "darker" is taken to be the name of the object and not a description of the relative saturation of a hue. Piaget (1928) has attributed the young child's difficulty with the relativity of relations to cognitive egocentricity. Young children are unable to envision multiple perspectives or points of view and hence misconstrue relations between concepts as absolute classes.

According to Flavell (1970), children develop a mastery of the fundamental properties of relations during the elementary school years, although their ability to grasp complicated relationships involving sophisticated reasoning may not develop until adolescence. Support for this contention comes from the research described by Klausmeier, Sipple, and Allen (1974a,b) discussed earlier. The authors report that the number and proportion of students successfully able to deal with questions designed to assess cognition of principles increased positively with age. By the ninth grade the majority of children were

able to answer principle-related questions correctly.

It is important to point out, however, that the research reported by Klausmeier, Sipple, and Allen involved no specific instruction. The principles tested for were not first taught to the students as part of the research. Rather, the students were asked questions which could be answered correctly only if the principle upon which they were based was known. Thus, this research should not be interpreted to mean that children below the ninth-grade level cannot be taught principles.

Summary. Very young children have difficulty understanding relational structures. However, they appear to develop mastery of the fundamental properties of relations during the elementary school years.

Research Related to Principle Learning and Teaching

There has been very little research reported dealing directly with principle learning or teaching. As Anderson (1973) has recently pointed out, "this is a topic about which pitifully little is known" (p. 26). In this section the work which has been undertaken in the area will be discussed.

A series of three studies carried out by Gagné and associates has focused on the effectiveness of practice examples that demonstrate application of a principle. Gagné, Mayor, Garstens, and Paradise (1962) studied the effect of the number of practice examples provided for subjects. Subjects were 136 seventh-grade students who worked through a learning program on the addition of integers. The program was broken down into a number of "subordinate knowledges" that were the principles upon which the final task, integer addition, was based. After each subordinate knowledge was mastered, subjects were given either one or two practice problems to which they were to apply the principle (low

repition condition) or four or five times as many practice problems (high repition condition).

At completion of the learning program tests of both subordinate knowledges and final performance (integer addition) were administered, although the authors reported results only for final task performance. Overall, there was no main effect for number of practice problems provided. When the high repetition condition was coupled with a guidance treatment in which subjects received guidance on how to integrate the material they were reading, performance was found to be better than that of subjects in a low repetition-low guidance condition. However, treatment programs varied in length, high repetition-high guidance being the longest while low repetition-low guidance was the shortest. It is possible, therefore, that the difference found between these treatments was due to the additional time spent working on the material and not to the number of practice problems and amount of guidance given. Indeed, the authors concluded that the overall effect of these variables was weak.

Gagné et al. (1965) investigated the effect of the amount of variety in practice problems provided. Subjects were 90 sixth-grade students. The learning task was a set of programmed self-instructional booklets on non-metric geometry. Again, the task was divided into a series of subordinate knowledges for which problem examples were provided. Many of the subordinate knowledges were principles. Variety in the practice problems constituted the experimental treatment. As in the earlier research, practice on these problems was provided only after initial attainment of the subordinate tasks.

Three levels of variety were used, defined as follows: El -

practice examples minimally different from those used to induce initial attainment (minimal variety); E2 - some E1 examples plus some of intermediate difference from teaching examples (intermediate variety); and E3 - some E1 and E2 examples plus some that were of maximal difference from teaching examples (maximal vairety). The difference between practice examples and teaching examples was defined in terms of the context in which the principle was to be applied. The number of examples was held constant across treatments and ranged from three to twelve depending upon the specific subordinate knowledge illustrated.

No differences among treatment groups were found on a test of subordinate knowledges (or on a test of final task performance) administered after completion of the learning program. Moreover, subjects in the maximal variety condition performed no better than control subjects who had received either no practice examples or irrelevant practice examples. Gagné et al. explained these results by suggesting that the nature of the material was so simple that additional practice examples were not needed after initial mastery.

An interesting follow-up to the Gagné et al. (1965) research was reported by Gagné and Bassler (1963). Nine weeks after the study described above was completed retention of the final (most complex) task taught and of each subordinate skill was measured. The results were that while there were no differences among means for retention of subordinate skills due to variety (or number) of practice examples, there was a difference for retention of the complex task. The minimal variety group had a significantly lower mean score on the complex task retention test than all other groups, lower even than subjects provided with no practice examples.

Traub (1966) reported a study in which a variety of subskill practice problems affected immediate learning of a complex task. Subskills were rules for carrying out graphical linear addition. Sixth-grade subjects read self-instructional programs which presented 20 heterogeneous subskill practice problems, 20 homogeneous subskill problems, or 20 irrelevant problems. After completing these problems subjects then worked 26 problems dealing with the complex task. Problem heterogeneity was defined as variation in problem context and type of correct answer. Heterogeneity was achieved by varying the portion of the number line employed and the size and sign of the correct answers.

Subjects who had been given heterogeneous subtask practice problems were able to solve significantly more complex task problems than either of the other groups. Subjects in the homogeneous and irrelevant groups appeared to adopt a problem solving strategy that resulted in a stereotyped error or else they gave no response at all.

A final study similar to those reported by Gagné and Traub was undertaken by Gibson (1970). Subjects participating in this research, third- and fourth-grade students, were given instruction on a unit dealing with decimal numbers. The unit was divided into three subskills (principles related to decimal numbers) which were taught to the subjects by their classroom teachers "in the usual manner." After initial instruction on each subskill a proficiency test was administered. Subjects unable to pass the proficiency test were given additional instruction until they could do so. Upon passing the proficiency test subjects were given practice examples (applications) of the principles to work on.

Practice examples of the principles varied in variety and number. Variety was defined as "the amount of diversity of context, form, and wording among the examples which involved application of the subordinate principles during the practice period" (p. 7). There were two levels of variety: broad and narrow. Narrow variety examples were similar in form to those used on a final posttest. Broad variety were not. Subjects were given either 10 or 25 practice problems.

Five experimental treatments were defined by the number and type of practice examples given. They were: broad variety, many examples; broad variety, few examples; narrow variety, many examples; narrow variety, few examples; and control, no practice examples. Four assessment tasks were used to measure treatment effects: an immediate learning test and a retention test that required subjects to recall the principles, and two transfer tests that required subjects to apply the principles in novel situations. No differences were found among treatment groups on any of the assessment tasks.

The results of the series of studies reported above are disappointing. Apparently, the number and the variety of practice examples of a principle do not affect the learning of that principle, although these variables may facilitate learning of a supraordinate principle. Perhaps the critical factor here is that none of these studies looked at instructional variables related to initial learning. Practice examples were always given after the principle had been taught, and at least in Gibson's research, mastered. It may be that only variables operative during the initial introduction of a principle have a significant effect upon learning.

Two studies that focused on instructional variables associated with the initial principle learning-teaching situation have been reported by

Gagne and Wiegand (1968) and Anderson (1973). Gagne and Wiegand's research looked specifically at the internal and external conditions of principle learning that Gagne (1970) has discussed. Fourth-grade subjects were taught principles composed of two elements, a "thing" (a drawn shape) and an "action" (such as underling the shape). During prelearning the individual elements of the principle were taught. Each thing or shape was associated with a name (a nonsense syllable) and subjects learned the association between shape and name by studying four labeled examples of the shape which varied along irrelevant dimensions. Actions were taught by requiring subjects to do whatever the action was.

Subjects learned the principles themselves from a printed, self-instructional booklet. Each page presented a different principle, and subjects studied three, five, seven, or nine principles depending upon condition. At the top of each page a previously learned shape was first presented and identified, e.g., this is a nob. Following that the statement of the principle was given, such as, a nob has a circle around it. The principle was then illustrated, and subjects were instructed to draw the principle themselves. Subjects studied the principles at a rate of approximately one every 15 seconds.

In Gagne and Wiegand's experimental procedure can be seen each of the conditions of principle learning that Gagne has postulated to be essential. Subjects were taught the concepts (elements) related in the principle, encouraged to recall those concepts, given a statement of the principle, and then required to demonstrate the principle. The authors report that this procedure was highly successful. Subjects learning up to five principles at a time were able to recall and demonstrate the

principles with 100% accuracy on tests of immediate retention.

It is important to point out, however, that in terms of both number of subconcepts and abstractness the principles Gagné and Wiegand taught must be classified as very simple. They were composed of only two concepts and for both of those concepts there were readily perceptible examples. If the principles had been more difficult or complex, it seems unlikely that they could have been grasped in a single 15-second trial and by the use of a single teaching example.

Support for the idea that difficult or complex principles cannot be taught by simply presenting the principle and one example of it comes from the research reported by Anderson (1973). Using printed materials, Anderson attempted to teach the principle "intermittent reinforcement causes resistance to extinction" to high school students. The principle is composed of five concepts, all of which could be considered relatively abstract in terms of the naiveté of the subject population.

Subjects read a three-page passage dealing with the principle. The first two pages introduced the component concepts. The third page explained reinforcement, the principle itself, and presented one example. The third page for a control group contained additional material on classical conditioning. After reading the passage all groups took a test that required them to apply the principle to situations that were identical, similar, or dissimilar to the text example.

Anderson reported that the treatment group performed significantly better than the control on the posttest, and also that performance was best on test items that were identical to text examples. Yet even when test items were identical, less than 60% of the treatment subjects were able to answer them correctly.

Indications of the type of additional instruction needed to teach difficult or complex principles comes from a body of recent literature dealing with the teaching of defined concepts (Feldman, 1972; Feldman & Klausmeier, 1974; Klausmeier & Feldman, 1974; Markle & Tiemann, 1969; Merrill & Tennyson, 1971; Markle & Tiemann, 1969, 1972; Swanson, 1972; Tennyson, 1973; Tennyson, Woolley, & Merrill, 1972). Defined concepts relate two or more simpler concepts in their definition. Because of this they can be considered in a formal sense a type of principle (Gagné, 1970). It is reasonable to presume, therefore, that variables which are effective in teaching defined concepts would be effective likewise in teaching principles.

As reported by Klausmeier and Feldman (1974), the instructional variables found to be most important in teaching defined concepts are the following:

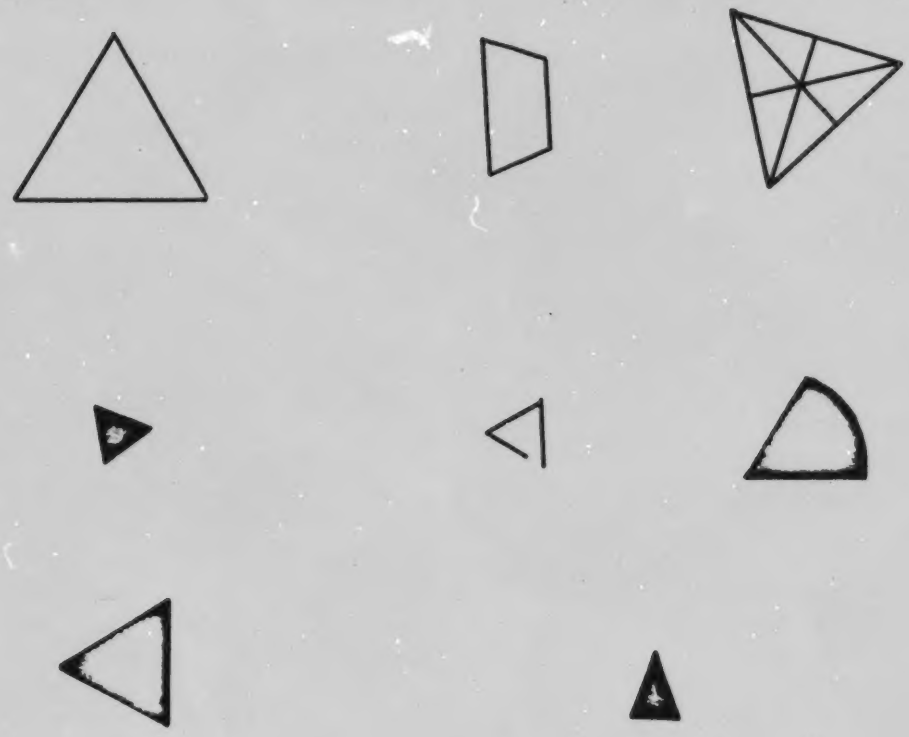
1) a rational set of examples and nonexamples of the concept;
2) a definition of the concept stated in terminology that is appropriate for the age level and abilities of the learner; and
3) cues or emphasizers, such as arrows or attention directing review questions, that draw the learner's attention to the relevant attributes of the concept.

Of the above variables, possibly the most important in terms of instructional design is the idea of a rational set of examples and non-examples. Originally conceived by Markle and Tiemann (1969), a rational set consists of enough concept examples to vary each major irrelevant attribute of the concept across the set, and enough non-examples so that a nonexample which lacks each relevant attribute

(while possessing as many of the other relevant attributes as possible) is presented. Thus the number of instances in a rational set if specific to the particular concept being taught and determined by the number of relevant and irrelevant attributes associated with that concept. Irrelevant attributes are defined as those properties which may or may not be common to every example of the concept while relevant attributes are those properties which are common to every example and, therefore, define the concept.

A rational set of examples and nonexamples for the concept equilateral triangle is presented in Figure 1. The examples vary in size, spatial orientation, and whether they are solid or line drawings. The nonexamples are constructed so that each of the relevant attributes of the concept (closed figure, simple figure, three straight sides, sides of equal length) is systematically excluded.

Merrill (1971) and Tennyson, Woolley, and Merrill (1972) have refined the idea of a rational set somewhat by pointing out the usefulness of matching teaching (labeled) examples and nonexamples whenever possible on irrelevant attributes. This serves to focus the learner's attention on the relevant attributes of the concept as they constitute the only difference between the instances. Of course, if the number of examples and nonexamples in a rational set is not equal, it is impossible to match each example with a corresponding nonexample. However, across the set examples and nonexamples can be used that share irrelevant attributes.



Examples Nonexamples

Figure 1. Rational set of examples and nonexamples for the concept equilateral triangle.

Klausmeier, Ghatala, and Frayer (1974) have pointed out that as an organizational first step in constructing a rational set and selecting an appropriate definition it is helpful to carry out a "concept analysis." Such an analysis consists basically of listing relevant and major irrelevant attributes of the concept and specifying a concept definition in terms of the relevant attributes. On the basis of the list of relevant and irrelevant attributes it is a relatively straightforward matter to select examples and nonexamples for a rational set. Additionally, the definition stated in the analysis can be modified as necessary to fit the characteristics of the learner population. Depending upon the needs of the instructor, the concept analysis itself can be expanded to include such elements as a list of principles or problem solving situations that involve use of the concept.

Tennyson and Tennyson (1974) have reported two experiments in which several of the instructional variables shown to facilitate the learning of defined concepts were extended to a principle learning situation. Subjects were high school sophomores who studied two transformational syntax rules: "extraposition" and "it deletion." Both rules could be applied to the same sentence and the behavioral objective was that the subjects would be able to apply either rule correctly when asked. The two principles were taught simultaneously.

The first experiment focused on the display variables of matching and divergence. Matching was analogous to a matched concept learning situation in which an example and a nonexample of a concept are paired on irrelevant attributes and presented together. In this study examples (applications) of each rule were paired on irrelevant attributes and presented simultaneously. The example of one rule served as the non-

example of the other and vice versa. Divergence referred to the type of within-rule teaching instances used. A divergent condition was one in which the irrelevant attributes of a rule were varied across examples, similar to the way irrelevant attributes are varied across examples in a rational set. On a test requiring subjects to apply each rule to ten nongrammatical sentences it was found that subjects who studied matched and divergent rule examples performed significantly better than subjects who studied non-paired divergent examples, paired non-divergent examples, or non-paired non-divergent examples.

In the second experiment Tennyson and Tennyson investigated the variables of analytical explantion and simultaneous presentation. Analytical explanation was analogous to emphasis from the concept learning literature: examples of the rules were presented with brief explanations. The simultaneous presentation condition was identical to the matched divergent condition of the first experiment. Examples of each rule were divergent and were presented either in pairs (simultaneous presentation) or independently (first one rule was introduced with examples and then the second rule was presented with examples). The authors reported that groups receiving a simultaneous presentation performed significantly better on a dependent measure than groups that received an independent presentation, and that groups provided with analytical explanations performed significantly better than groups not provided with such explanations. Across the two experiments subjects performed best when given simultaneous presentation of examples (matched and divergent) with analytic explanation. These subjects responded to 90% of the items on the dependent measure correctly.

While the results of Tennyson and Tennyson's research is important in that the authors have demonstrated the applicability of certain concept learning instructional variables to principle learning situations, the results are not easily generalized. As Tennyson and Tennyson point out, a simultaneous presentation condition necessitates that the principles have similar effective stimuli and similar irrelevant attributes. Pairs of principles meeting these criteria can be assumed to be relatively rare.

Summary. Very little research dealing with principle learning and teaching has been undertaken. Nevertheless, it has been demonstrated that (1) additional practice examples of a principle presented after initial learning do not affect attainment of the principle, and (2) "simple" principles can be learned from a statement of the principle and a single labeled example if the concepts related in the principle are familiar to the students. Indications of the type of additional instruction needed to learn "complex" principles comes from the literature on concept learning. Several of these variables have been shown to facilitate principle learning but only (so far) under rather unique conditions.

The Present Research

The present research was designed to investigate the effect of two instructional variables on the learning of easy (or simple) and difficult (or complex) principles. The two variables were instruction on the concepts related in the principle and type of instances used to illustrate the principle. The idea of a "rational set" of concept examples and nonexamples was extended to principles, and [illegible]rred to as a "rationally selected" set. Based on the results of Gagné and Wiegand

(1970) and Anderson (1973), it was expected that the effectiveness of a particular instructional strategy would be dependent upon whether an easy or a difficult principle were being studied.

The following specific results were hypothesized:

(1) Easy principles would be mastered more full than difficult principles.

(2) Subjects instructed on the separate concepts contained in the principles would perform significantly better than subjects not receiving such instruction.

(3) Subjects receiving a statement of the principle and either a rationally selected set of examples and nonexamples or one example would perform significantly better than control subjects who did not receive a statement of the principle or any illustrative instances.

(4) (a) For a difficult principle a rationally selected set of instances would be more facilitative than one example regardless of whether subjects had received instruction on the concepts or not.

(b) For a simple principle a rationally selected set of instances would be equally effective as one example if subjects had received instruction on the concepts contained in the principle. If subjects had not received instruction on the target concepts, a rationally selected set would be more facilitative than one example.

Chapter III

METHOD

Subjects

Subjects were 159 fifth-grade students, 81 females and 78 males, from a suburban community in south-central Wisconsin. They were of average ability and socioeconomic status. Reading achievement scores on the Metropolitan Achievement Test (Test F) which was administered during the fall of the school year were obtained for each child to be used as a covariate in analyzing the results of the study. The average achievement score was 78, which corresponded to a grade equivalency of 5.6. Subjects were randomly assigned within sex groups to an experimental condition.

Learning Task

Selection of Principles. An "easy" principle and a "difficult" principle from two curriculum areas were used in the learning task. The curriculum areas were mathematics and language arts. Thus, four different principles were taught.

The four principles used in the learning task were selected from those which Klausmeier, Sipple, and Allen (1974a,b) had employed in their cross-sectional study of concept attainment. In that research the same subjects were asked to answer questions based on several principles from three separate curriculum areas, two of which were

mathematics and language arts. The percentage of subjects correctly able to answer principle related questions within a particular discipline varied from principle to principle and also from grade to grade. Thus, it was possible to order the principles within a subject matter and within a grade level according to the percentage of subjects correctly able to answer questions related to them.

For the present research, the principles that generated questions which the highest percentage of subjects could answer were operationally defined as "easy," while those that generated questions which the lowest percentage of subjects could answer were operationally defined as "difficult." Based on results Klausmeier et al. obtained from the sixth-grade population, the easiest and most difficult principle from language arts, and the easiest and most difficult principle from mathematics, were used in the present research.[1] These principles, along with the percentages of subjects (from the Klausmeier et al. research) correctly able to answer questions about them, are presented in Table 1.

Principles used in the present research were selected in the above manner because this allowed the categories "easy" and "difficult" to be defined operationally in terms of empirical results rather than on the basis of some subjective criterion. While the subject pool Klausmeier et al. used was not identical to that used in the present research, it was felt that the high similarity between the two in terms of age, ability, and socioeconomic status justified the use in the present research of results obtained by Klausmeier et al.

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[1] Actually, the converse of the easiest mathematics principle was used in the present study. Questions related to the converse were identified by only 1% fewer subjects (54% vs. 53%). As the converse was stated in a form more easily explainable by short, printed lessons, it was designated the "easy" principle.

Table 1.

Percentage of Sixth-Grade Students Correctly Able to Answer Principle-Related Questions for "Easy" and "Difficult" Principles from Mathematics and Language Arts[1]

Mathematics - "Easy" Principle

Statement of Principle: If the three angles of a triangle are equal in number of degrees, the sides of the triangle are equal in length.

Percentage: 53%

Mathematics - "Difficult" Principle

Statement of Principle: All equilateral triangles are similar in shape.

Percentage: 16%

Language Arts - "Easy" Principle

Statement of Principle: A singular noun names one person, place, or thing. A plural noun names more than one person, place, or thing.

Percentage: 38%

Language Arts - "Difficult" Principle

Statement of Principle: A proper noun is capitalized. A common noun is not capitalized.

Percentage: 10%

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[1] The principles used in the present study and presented in Table 1 were stated in the same way that Klausmeier, et al. stated them with two minor exceptions. a) The difficult math principle did not include the words "in shape" in the Klausmeier research. These words were added so that the sense of the word "similar" would correspond to the mathematical definition of similar presented in the Subconcept-Training lesson. b) Klausmeier et al. included within the language arts difficult principle a brief description of what a common and proper noun were. In the present research definitions of these words were presented in the Subconcept-Training lesson.

It should be noted that the percentage of sixth-grade students correctly able to answer principle related questions in the Klausmeier et al. study does not range from 100% to 0%. The range is much less broad, and negatively skewed. This demonstrates that the majority of subjects were unfamiliar with these principles. Due to the similarity between subject populations, it can be assumed, therefore, that the subjects in the present research were unfamiliar with the principles as well.

Treatment Lessons. Two printed, sequential lessons were constructed to teach each principle. The first lesson (Subconcept-Training) presented the major concepts related in the principle and was designed to teach these concepts to the formal level using the procedures outlined by Klausmeier and Feldman (1974). This consisted of defining each concept at a level appropriate for fifth-grade students (the definition was set off in a box at the top of the page), illustrating each concept with a labeled rational set of examples and nonexamples, and emphasizing the relevant attributes of each concept by explaining why the examples were examples and the nonexamples not examples.

The concepts were not presented in the same order as they occurred in the principle relating them. Rather, they were presented in a random sequence unless the sense of a particular concept dictated that certain other concepts precede or follow it.

At the end of each Subconcept-Training lesson a page of review questions dealing with the concepts was presented. These questions were straightforward and designed to be easily answered. They were considered a review of the material and not a test. Subjects were

encouraged to turn back and reread relevant material if they had any difficulty. Correct answers were presented on the following page to provide subjects with immediate feedback.

The primary concepts taught in the four Subconcept-Training lessons were as follows:

Mathematics - easy principle: Angle, triangle, side.

Mathematics - difficult principle: Equilateral, triangle, similar, shape.

Language Arts - eay principle: Singular, noun, plural.

Language Arts - difficult principle: Noun (proper and common), capitalized.

In order to prepare the Subconcept-Training lessons the concepts themselves were first analyzed. The defining attributes and irrelevant attributes of the concept were specified, a definition in terms of defining attributes was constructed, and a rational set of examples and nonexamples was selected according to procedures outlined by Markle and Tiemann (1969).

A variety of texts served as sources of information for carrying out the concept analyses: Elementary School English (1967); English Grammar and Composition (1957); Exploring Elementary Mathematics, Grades 5 and 6 (1970); Webster's New World Dictionary : Elementary Edition (1966); Webster's Seventh New Collegiate Dictionary (1965); Webster's Third New International Dictionary (1971). The fifth-grade texts and children's dictionary were used not only to provide relevant content but also to indicate the level of technicality and completeness that was appropriate for fifth-grade students studying these concepts. At times the definition of a particular concept was taken directly from one of these texts.

At other times the definition was constructed from information presented in several sources. The concept analyses are presented in Appendix A.

At no time were the principles relating the concepts presented in the Subconcept-Training lessons. Nor was any attempt made to relate concepts to each other in any other way, except in cases in which the particular meaning of a concept that the lesson was designed to present necessitated the modification of one concept by another. For example, the word shape presented in the lesson for the difficult mathematics principle was first introduced in a general sense and then associated with the word similar so that the mathematical meaning of "similar" figures could be explained.

The four Subconcept-Training lessons were the same length in terms of number of pages (12 pages) regardless of the principle upon which they were based. This was done so that the lessons would take approximately the same length of time to complete and would appear to be as similar as possible to the subjects. As some lessons presented more concepts than others, the amount of material presented on each page could not be equated across lessons. The four lessons are presented in Appendix B.

The second of the two sequential teaching lessons (Principle-Training) presented the principle itself. The principle was introduced in a box at the top of the first page and was followed by either a rationally selected set of examples and nonexamples or by one example. At the end of the instructional material the subjects were directed in their lessons to go back and read the lesson once more.

In order to construct the Principle-Training lessons the four principles were first analyzed in a manner similar to the way in which concepts are analyzed. The principle was stated, and from the statement a list of relevant and irrelevant "attributes" was constructed. Relevant "attributes" were taken to be those aspects of the principle which were present in every correct demonstration, or example, of the principle. For instance, in the principle "all equilateral triangles are similar in shape," the concept equilateral triangle is a relevant attribute. Irrelevant "attributes" were taken to be those aspects of the principle which either varied from example to example or did not have to be present in every example. For instance, the number of equilateral triangles used to illustrate "all equilateral triangles are similar in shape," or the size of the triangles, were considered irrelevant attributes.

On the basis of the list of relevant and irrelevant attributes a rationally selected set of examples and nonexamples was developed for each principle. Enough examples were specified so that all of the major irrelevant attributes of the principle were thoroughly varied. Enough nonexamples were specified so that each of the relevant attributes of the principle could be systematically excluded. Examples and nonexamples had similar irrelevant attributes.

The final element of the analysis of each principle consisted of the specification of several problem solving situations involving the principle. The analyses for each of the four principles are presented in Appendix C.

All Principle-Training lessons that included a rationally selected set of examples and nonexamples were five pages long. In those lessons that included only one example three pages of placebo material were

added so that all subjects would read treatment lessons of equal length. To compensate for any possible effects due to the order in which the placebo material was presented in relation to the principle and example (principle and example followed by placebo material or vice versa), half of these booklets for each principle were prepared with the placebo material coming first and half with the placebo material coming last.

The examples used in the booklets which contained only one illustration of a principle were taken from the rationally selected sets. To eliminate any effects due to the particular example chosen, several versions of these lessons were constructed for each principle and each version included a different example.

The Principle-Training lessons are presented in Appendix D. Only the four lessons which contain a rationally selected set of examples and nonexamples are included.

Readability of Experimental Lessons

Readability or difficulty of the experimental lessons was determined using the Dale-Chall formula for predicting readability (Dale & Chall, 1948). All lessons, Subconcept-Training, Principle-Training, and placebo, were found to be written at a fifth- to sixth-grade level. This level was considered appropriate for the subject population.

In addition, to insure that all subjects had at least some familiarity with any potentially difficult words in the lessons, a list of these words was compiled and included at the beginning of the Subconcept-Training lessons and corresponding placebo lessons. This list covered all experimental lessons and included words identified as "unfamiliar" on the basis of the Dale-Chall readability calculations and on the basis of the pilot study. These words were reviewed with the

subjects before any lessons were read.

Placebo Lessons

Two printed placebo lessons were prepared that were equal in length to the two types of treatment lessons (Subconcept-Training and Principle-Training). The first placebo lesson dealt with subconcepts included in the definition of the concept tree. The second placebo lesson dealt with the concept Roman numerals.

Dependent Measures

A test on each of the four principles was constructed. The tests were structurally as similar as possible and varied among each other only in content. These tests are included as Appendix E.

Each of the four tests was sixteen items long and contained two types of questions: knowledge questions and application questions. Knowledge questions were items which required subjects to recognize both a statement of the principle and correct applications or examples of the principle. These items were designed to test subjects' ability to recognize or recall specific elements presented in the lessons. Application questions were items which required subjects to actually apply the principle in problem solving situations. These items were designed to test subjects' ability to go beyond the specific content of the lessons. An equal number of knowledge and application items were included on each dependent measure.

The principle related items from Klausmeier, Sipple, and Allen (1974a,b) which were used to determine the difficulty of the principles were included as part of the sixteen items on each dependent measure. They too were classified in the manner described above as either knowledge

or application items. At least one of each type was based on each principle.

The four tests were presented in printed booklets similar in form to the lesson booklets. Instructions for completing the tests were included at the beginning of the booklets and were identical for all principles. Within the instructions were several sample items, one corresponding in form to each of the different types of question formats used on the tests (true-false type items and two multiple-choice forms). The sample items were included so that subjects would know what type of questions to expect and also how to mark their answers correctly.

Treatment Program

For each of the four principles taught, six treatment programs, or experimental conditions, were defined. Every subject was randomly assigned to both a treatment program and to a principle. Thus, each subject read materials dealing with only one principle and took the dependent measure on that principle alone.

The six treatment programs, which were identical across principles, were as follows:

ST-RS. Subjects in this treatment read a Subconcept-Training lesson and a Principle-Training lesson. The Principle-Training lesson presented a rationally selected set of examples and nonexamples.

ST-1. Subjects in this treatment read a Subconcept-Training lesson and a Principle-Training lesson. The Principle-Training lesson presented one example.

ST-0. Subjects in this treatment read a Subconcept-Training lesson and a placebo lesson. This condition was included to determine whether subjects who had not been presented with the statement of a principle

(or instances of it) could accurately deduce the principle from its subconcepts.

0-RS. Subjects in this treatment read a placebo lesson and a Principle-Training lesson. The Principle-Training lesson presented a rationally selected set of examples and nonexamples and was identical to the Principle-Training lesson used in treatment ST-RS.

0-1. Subjects in this treatment read a placebo lesson and a Principle-Training lesson. The Principle-Training lesson presented one example and was identical to the Principle-Training lesson used in treatment ST-1.

0-0. Subjects in this treatment read two placebo lessons. They served as control subjects.

Procedure

Prior to experimentation half of the lesson booklets for each treatment program were designated for boys and half for girls to insure that an equal number of each sex were included in each treatment. Within sex grouping the treatment materials were then put in a random order.

Two experimenters (the author and a co-worker) working as a team conducted the study. One experimenter (the author) gave directions, distributed materials, and answered questions. The second experimenter distributed materials and answered questions only. In the majority of cases testing was done in the classroom with the classroom teacher present. However, in two instances in which fifth- and sixth-grade students were taught together as one unit, the fifth graders were taken to a designated testing area so as not to disturb their fellows.

At the start of the teaching-testing session both experimenters were introduced and the general purpose and nature of the study were explained. Subjects were told that they would be reading two lessons and then "asnwering some questions." Experimental materials were then distributed to each subject. The materials were prepackaged in large brown envelopes to insure that the proper sequence of lessons and test was received. One experimenter passed out the materials designated for boys and the other experimenter passed out the materials designated for girls. As the treatment materials were randomized within sex group, subjects were thus randomly assigned to an experimental condition.

Subjects were initially told to remove only the two lesson booklets from their envelopes. Both lesson and test booklets were color coded to help subjects determine which booklet they were to be working on at any particular time.

The actual experimentation began with a review of the word list contained in the first lesson booklet (Subconcept-Training or placebo). It was explained to the subjects that these were difficult words which they might find in the lessons they were going to read. The experimenter reviewed the list by first pronouncing each word and then asking the subjects to pronounce the word together. Each word on the list was covered in this manner. This procedure was designed to insure that subjects could at least pronounce all potentially troublesome words.

After reviewing the word list, subjects were told to turn the page and begin reading the first booklet silently. When finished with the first booklet they were told to immediately go on to the second. Subjects were allowed to turn back and reread passages which were un-

clear to them within the booklet they were reading; they were not allowed to turn back to the first booklet once they had begun to read the second. All subjects were given sufficient time to read both booklets. Most subjects finished reading in about 25 minutes. Subjects who completed their lessons before all others were finished were told to sit quietly at their desks and wait.

After all subjects had finished reading both lessons, the lessons were collected and subjects were instructed to remove the dependent measure from their envelopes. The experimenter read the instructions for the dependent measure aloud while the subjects followed along in their own booklets. The experimenter also reviewed the three sample items which were included as part of the instructions. Subjects were then directed to begin work independently on the rest of the booklet. All subjects were given as much time as they needed to complete the dependent measure.

During the entire experimental session the experimenters answered questions dealing only with the pronunciation of words and the clarification of instructions. In total the session lasted between 45 minutes and one hour. All subjects appeared to be highly attentive throughout the experimental session and seemed to work through their materials conscientiously. The instructions to the students are included in Appendix F.

Pilot Study

The treatment materials, procedure, and experimenter's instructions were pilot tested on a subsample of the target population to evaluate their clarity and appropriateness for fifth-grade students.

The pilot study was also undertaken to yield estimates of the time required to administer the materials. Subjects were 31 students from the same Wisconsin community in which the major experimentation was carried out.

Ambiguities and other difficulties with the materials, procedure, and instructions were noted and used as a basis for revisions. Due to the large number of treatment conditions piloted (in several cases only one subject received a particular treatment), no meaningful statistical analysis of the subjects' responses on the various tests could be done. However, in general subjects receiving instruction appeared to perform better than control subjects (63% correct vs. 70% correct) although there did not seem to be an effect for instruction on subconcepts (71% correct for training, 75% correct for no training). Subjects completed the materials in approximately 50 minutes. No differences in time spent reading due to treatment were evident.

Experimental Design

The experiment employed a 2 x 2 x 3 x 2 x 2 factorial design. A covariate, subject's reading achievement score , was also included in the design. The five factors and the levels within each factor were as follows:

a) training on subconcepts: training or no training

b) type of principle: easy or difficult

c) mode of principle presentation: principle statement with rationally selected set of instances, principle statement with one example, or no principle statement and no illustrative instances

d) subject matter: language arts or mathematics

e) sex of subject.

Chapter IV

RESULTS

Two scores were calculated for each subject from the tests: total score on knowledge items and total score on application items. Mean scores for each item type were then analyzed separately by analysis of covariance. Analyses were carried out using the General Linear Hypothesis (GLH) computer program (Kuhn, 1971). The covariate in both cases was subject's reading achievement score on the Metropolitan Achievement Test. This score was selected as a covariate to reduce variability due to differences in reading ability.

It was presumed that some dependency between knowledge and application items would exist. Logically it is unreasonable to expect that a subject would be able to apply a principle correctly without being able to recognize a correct application of that principle (although Gagné (1970) says that a learner may be able to apply a principle without being able to accurately state the principle). Therefore, it was expected that scores on application items would depend upon scores on knowledge items. However, possible relationships between knowledge and application items were not of concern in the present study and consequently the two dependent measures were analyzed separately. The interested reader is referred to Appendix G which presents an analysis of covariance using difference scores (knowledge - application) as the data.

The significance level per test adopted in the present experiment was .05. Results related to the specific hypotheses of the experiment tested at this level, as well as significant results for effects about which predictions were not made, will be reported separately for knowledge and application items. The specific hypotheses tested were the following:

1) Easy principles would be mastered more fully than difficult principles.
2) Subjects instructed on the separate concepts contained in the principles would perform significantly better than subjects not receiving such instruction.
3) Subjects receiving a statement of the principle and either a rationally selected set of examples and nonexamples or one example would perform significantly better than control subjects who did not receive a statement of the principle or any illustrative instances.
4) (a) For a difficult principle a rationally selected set of instances would be more facilitative than one example regardless of whether subjects had received instruction on the concepts or not.

   (b) For a simple principle a rationally selected set of instances would be equally effective as one example if subjects had received instruction on the concepts contained in the principle. If subjects had not received instruction on the target concepts, a rationally selected set would be more facilitative than one example.

Knowledge Items

Adjusted means (adjusted for the effect of the covariate), adjusted variances, and cell sizes for each cell in the design are presented in Tables 2 and 3. Raw score means with variances and cell sizes are given in Appendix H.

Results of the analysis of covariance are presented in Table 4. None of the main effects were significant at the specified .05 level. However, means for main effects about which specific hypotheses were made (type of principle, training on concepts, and mode of presentation) were all in the predicted directions. Moreover, effects for type of principle and mode of presentation approached significance ($p < .10$). Means for the five main effects are presented in Tables 5 and 6.

The interaction of interest in the experiment was type of principle by training on concepts by mode of presentation. The interaction was not significant. Means for this interaction are given in Table 7.

Two interactions for which specific predictions had not been made, subject matter by type of principle and sex by type of principle by mode of presentation, were found to be significant. Means for the subject matter by type of principle interaction are presented in Table 8. It is clear from the means that the difference between easy and difficult principles for language arts (.024) was much less than the difference between easy and difficult principles for mathematics (.779). Additionally, while the difference was in the predicted direction for mathematics (higher performance on easy principle than on difficult), the difference was in the opposite direction for language arts. Due to the small magnitude of the difference, however, this reversal of pre-

Table 2.

Adjusted Means, Adjusted Variances, and Cell Sizes for Knowledge Items

Language Arts Principles

		Mode of Presentation					
		Set		One Example		Placebo	
		Males	Females	Males	Females	Males	Females
Training on Subconcepts	Easy Principle	6.018 (3.155) n=3	6.862 (1.482) n=5	6.487 (0.639) n=3	6.969 (1.004) n=4	7.611 (0.510) n=3	6.045 (0.008) n=2
	Difficult Principle	7.483 (0.554) n=4	6.207 (5.810) n=3	7.213 (0.521) n=3	7.967 (0.113) n=4	6.340 (0.024) n=3	7.068 (0.642) n=3
No Training on Subconcepts	Easy Principle	6.915 (4.262) n=3	7.980 (0.116) n=3	4.726 (2.085) n=3	7.714 (0.485) n=3	6.971 (0.647) n=3	6.421 (0.764) n=4
	Difficult Principle	7.003 (0.208) n=3	6.452 (0.693) n=4	7.360 (0.515) n=3	7.024 (2.508) n=3	5.257 (3.368) n=3	5.733 (5.922) n=4

Table 3.

Adjusted Means, Adjusted Variances, and Cell Sizes for Knowledge Items

Mathematics Principles

		Mode of Presentation					
		Set		One Example		Placebo	
		Males	Females	Males	Females	Males	Females
Training on Subconcepts	Easy Principle	7.172 (0.284) n=3	6.983 (0.500) n=4	6.845 (1.771) n=4	6.564 (0.503) n=3	7.480 (0.148) n=4	6.172 (2.013) n=3
	Difficult Principle	7.715 (0.564) n=4	6.396 (0.216) n=3	6.818 (1.155) n=3	4.589 (2.981) n=4	5.124 (0.068) n=3	6.499 (4.204) n=3
No Training on Subconcepts	Easy Principle	6.576 (0.452) n=4	7.048 (0.004) n=3	7.714 (0.231) n=3	6.859 (0.322) n=3	6.168 (0.219) n=3	7.275 (0.807) n=3
	Difficult Principle	6.452 (3.166) n=4	5.892 (2.735) n=4	5.983 (7.151) n=3	7.113 (0.083) n=3	5.746 (5.187) n=3	5.251 (1.229) n=3

Table 4.

Univariate Analysis of Covariance for Total Test Scores on Knowledge Items

Source	df	MS	F	
Sex	1	0.006	0.0039	
Subject Matter	1	2.477	1.6335	
Type (easy-difficult)	1	5.631	3.7134	*
Training	1	0.647	0.4264	
Mode of Presentation	2	3.591	2.3681	*
Sex x Subject Matter	1	2.901	1.9131	
Sex x Type	1	1.663	1.0967	
Sex x Training	1	4.399	2.9009	*
Sex x Mode of Presentation	2	0.436	0.2875	
Subject Matter x Type	1	6.829	4.5034	**
Subject Matter x Training	1	0.719	0.4743	
Subject Matter x Mode	2	0.350	0.2309	
Type x Training	1	1.426	0.9404	
Type x Mode	2	3.052	2.0127	
Training x Mode	2	1.276	0.8415	
Sex x Subject Matter x Type	1	0.548	0.3614	
Sex x Subject Matter x Training	1	0.295	0.1945	
Sex x Subject Matter x Mode	2	2.934	1.9348	
Sex x Type x Training	1	1.064	0.7017	
Sex x Type x Mode	2	5.777	3.8097	**
Sex x Training x Mode	2	0.486	0.3205	
Subject Matter x Type x Training	1	0.515	0.3396	
Subject Matter x Type x Mode	2	2.412	1.5906	
Subject Matter x Training x Mode	2	4.329	2.8550	*
Type x Training x Mode	2	0.916	0.6040	
Regression due to higher order interactions	11	1.991	1.3130	
Error	110	1.5164		

** $p < .05$

* $p < .10$

Table 5.

Adjusted Means, Adjusted Variances, and Cell Sizes for Knowledge Items

Main Effects for Sex and Subject Matter

Main Effect for Sex

Males	Females
6.668 (1.704) n=78	6.616 (1.739) n=81

Main Effect for Subject Matter

Language Arts	Mathematics
6.762 (1.702) n=79	6.523 (1.714) n=80

Table 6.

Adjusted Means, Adjusted Variances, and Cell Sizes
for Knowledge Items
Main Effects for Type of Principle, Training,
and Mode of Presentation

Main Effect for Type of Principle

Easy	Difficult
6.832 (1.110) n=79	6.454 (2.256) n=80

Main Effect for Training

Training	No Training
6.736 (1.487) n=81	6.544 (1.948) n=78

Main Effect for Mode of Presentation

Set	One Example	Placebo
6.820 (1.396) n=57	6.735 (1.906) n=52	6.342 (1.802) n=50

Table 7.

Adjusted Means, Adjusted Variances, and Cell Sizes
for Type of Principle by Training
by Mode of Presentation Interaction

Knowledge Items

		Mode of Presentation		
		Set	One Example	Placebo
Easy Principle	Training	6.787 (1.193) n=15	6.744 (0.858) n=14	6.947 (1.035) n=12
	No Training	7.087 (1.138) n=13	6.753 (2.196) n=12	6.689 (0.668) n=13
Difficult Principle	Training	7.043 (1.641) n=14	6.594 (2.889) n=14	6.258 (1.445) n=12
	No Training	6.413 (1.596) n=15	6.870 (2.168) n=12	5.515 (3.175) n=13

Table 8.

Adjusted Means, Adjusted Variances, and Cell Sizes for Subject Matter by Type of Principle Interaction**

Knowledge Items

	Subject Matter	
	Language Arts	Mathematics
Easy Principle	6.750 (1.595) n=39	6.911 (0.652) n=40
Difficult Principle	6.774 (1.850) n=40	6.134 (2.510) n=40

** $p < .05$

dicted direction cannot be considered meaningful.

Table 9 presents the means for the sex by type of principle by mode of presentation interaction. Inspection of the means reveals that the interaction was due in part to the fact that for females performance was higher on the easy principles than on the difficult principles while for males performance generally was higher on the difficult principles than on the easy principles. Differences in the ordering of condition means within rows resulted in the three-way interaction.

Effects for all 4-way and 5-way interactions were pooled and tested as a residual sum of squares. These higher order interactions were considered uninterpretable and were included in the design only to reduce the error variance. The effects of the higher order interactions were found to be nonsignificant.

Application Items

Tables 10 and 11 present the adjusted means, adjusted variances, and cell sizes for application items. Raw score means with variances and cell sizes are given in Appendix H.

The analysis of covariance results are presented in Table 12. Main effects for subject matter and for mode of presentation were both found to be significant. Means for these effects and all other main effects are presented in Tables 13 and 14.

Inspection of the means for the effect of subject matter (Table 13) reveals that performance was higher for mathematics principles than for language arts principles. This finding is consistent with the statistics for these principles calculated from the data reported by Klausmeier, Sipple, and Allen (1974a,b). In that research higher percentages of

Table 9.

Adjusted Means, Adjusted Variances, and Cell Sizes
for Sex by Type of Principle
by Mode of Presentation Interaction**

Knowledge Items

		Mode of Presentation		
		Set	One Example	Placebo
Female	Easy Principle	7.155 (0.857) n=15	7.022 (0.806) n=13	6.509 (0.977) n=12
	Difficult Principle	6.227 (1.332) n=14	6.617 (1.742) n=14	6.107 (1.730) n=13
Male	Easy Principle	6.663 (1.258) n=13	6.474 (1.459) n=13	7.092 (0.774) n=13
	Difficult Principle	7.174 (1.102) n=15	6.843 (1.418) n=12	5.617 (1.394) n=12

** $p < .05$

Table 10.

Adjusted Means, Adjusted Variances, and Cell Sizes for Application Items

Language Arts Principles

		Mode of Presentation					
		Set		One Example		Placebo	
		Males	Females	Males	Females	Males	Females
Training on Subconcepts	Easy Principle	2.503 (0.950) n=3	6.343 (0.993) n=5	5.374 (5.445) n=3	5.657 (8.456) n=4	6.192 (2.078) n=3	0.554 (0.663) n=2
	Difficult Principle	6.479 (0.714) n=4	3.660 (2.630) n=3	7.186 (0.958) n=3	3.460 (1.900) n=4	4.267 (13.049) n=3	4.676 (8.302) n=3
No Training on Subconcepts	Easy Principle	3.710 (3.458) n=3	7.716 (0.086) n=3	2.220 (1.328) n=3	6.651 (0.588) n=3	4.716 (8.583) n=3	4.653 (5.634) n=4
	Difficult Principle	5.004 (3.581) n=3	5.691 (1.133) n=4	6.292 (1.465) n=3	5.029 (4.921) n=3	4.833 (3.245) n=3	4.229 (3.612) n=4

Table 11.

Adjusted Means, Adjusted Variances, and Cell Sizes for Application Items

Mathematics Principles

		Mode of Presentation					
		Set		One Example		Placebo	
		Males	Females	Males	Females	Males	Females
Training on Subconcepts	Easy Principle	5.469 (3.877) n=3	5.729 (4.757) n=4	5.256 (6.819) n=4	6.948 (3.158) n=3	5.281 (6.119) n=4	3.802 (0.017) n=3
	Difficult Principle	7.512 1.591 n=4	6.150 (3.785) n=3	5.110 (2.372) n=3	5.914 (2.336) n=4	5.225 (1.515) n=3	5.276 (8.558) n=3
No Training on Subconcepts	Easy Principle	6.842 (4.208) n=4	6.984 (1.080) n=3	4.984 (2.990) n=3	4.494 (7.940) n=3	4.206 (6.418) n=3	6.928 (1.410) n=3
	Difficult Principle	5.441 (1.113) n=4	5.563 (5.703) n=4	5.312 (4.449) n=3	5.990 (3.114) n=3	4.912 (0.141) n=3	4.973 (4.658) n=3

Table 12.

Univariate Analysis of Covariance for Total Test Scores on Application Items

Source	df	MS	F	
Sex	1	1.035	0.2901	
Subject Matter	1	17.430	4.8860	**
Type (easy-difficult)	1	1.009	0.2828	
Training	1	0.355	0.0995	
Mode of Presentation	2	13.990	3.9217	**
Sex x Subject Matter	1	0.658	0.1844	
Sex x Type	1	21.320	5.9765	**
Sex x Training	1	21.990	6.1643	**
Sex x Mode of Presentation	2	4.751	1.3318	
Subject Matter x Type	1	1.002	0.2809	
Subject Matter x Training	1	0.817	0.2291	
Subject Matter x Mode	2	1.829	0.5127	
Type x Training	1	1.821	0.5105	
Type x Mode	2	0.446	0.1252	
Training x Mode	2	3.129	0.8771	
Sex x Subject Matter x Type	1	13.360	3.7451	*
Sex x Subject Matter x Training	1	7.037	1.8173	
Sex x Subject Matter x Mode	2	10.790	3.0247	*
Sex x Type x Training	1	8.492	2.3805	
Sex x Type x Mode	2	14.080	3.9470	**
Sex x Training x Mode	2	6.682	1.8731	
Subject Matter x Type x Training	1	1.725	0.4836	
Subject Matter x Type x Mode	2	0.017	0.0047	
Subject Matter x Training x Mode	2	0.199	0.0557	
Type x Training x Mode	2	9.749	2.7329	*
Regression due to higher order interactions	11	6.918	1.9393	**
Error	110	3.5673		

** $p < .05$

* $p < .10$

Table 13.

Adjusted Means, Adjusted Variances, and Cell Sizes
for Application Items
Main Effects for Sex and Subject Matter

Main Effect for Sex

Males	Females
5.254 (4.069) n=78	5.361 (4.363) n=81

Main Effect for Subject Matter **

Language Arts	Mathematics
4.982 (4.775) n=79	5.631 (3.464) n=80

** $p < .05$

Table 14.

Adjusted Means, Adjusted Variances, and Cell Sizes
for Application Items
Main Effects for Type of Principle, Training,
and Mode of Presentation

Main Effect for Type of Principle

Easy	Difficult
5.256 (5.095) n=79	5.361 (3.354) n=80

Main Effect for Training

Training	No Training
5.302 (4.678) n=81	5.315 (3.747) n=78

Main Effect for Mode of Presentation **

Set	One Example	Placebo
5.760 (3.534) n=57	5.345 (4.141) n=52	4.756 (4.626) n=50

** $p < .05$

children were able to answer mathematics principles than were able to answer language arts principles.

The means for the effect of mode of presentation (Table 14) were in the predicted direction. Subjects receiving a statement of the principle and a rationally selected set of instances performed better than subjects receiving only a statement of the principle and one example, who in turn performed better than control subjects. However, pairwise comparisons among the means using a Scheffé procedure appropriate for analysis of covariance

$$\underline{S} = \sqrt{(k-1)(F^{\alpha},{}^{\nu}_{1},{}^{\nu}_{2})}\sqrt{MS_E\left[\sum\frac{(cj)^2}{nj} + \frac{\hat{\psi}^2_{(cov)}}{SS_{E(cov)}}\right]}$$

suggested by Scheffé (1959), revealed that only the group receiving a rationally selected set with the principle performed significantly better than control subjects who did not receive a statement of the principle or any illustrative instances ($\underline{S}$ = .9064, $\bar{x}_1 - \bar{x}_3$ = 1.004). The difference between the group receiving a statement of the principle and one example and the control group approached significance ($\underline{S}$ = .4345 for $\underline{p} < .10$, $\bar{x}_2 - \bar{x}_3$ = .589).

Means for the main effects of training on concepts and type of principle (Table 14) were not in the predicted direction. However, these differences were not significant.

The interaction of interest, type of principle by training on concepts by mode of presentation, was marginally significant (actually, $\underline{p} < .07$). Means for this interaction are presented in Table 15. Because this interaction was of central importance in the study, three comparisons among the means were carried out to test the specific hypotheses of interest. The first comparison compared the effect of

Table 15.

Adjusted Means, Adjusted Variances, and Cell Sizes
for Type of Principle by Training
by Mode of Presentation Interaction*

Application Items

		Mode of Presentation		
		Set	One Example	Placebo
Easy Principle	Training	[1] 5.237 (4.113) n=15	[2] 5.758 (5.290) n=14	[3] 4.351 (6.051) n=12
	No Training	[4] 6.354 (4.213) n=13	[5] 4.587 (5.071) n=12	[6] 5.089 (5.283) n=13
Difficult Principle	Training	[7] 6.100 (3.552) n=14	[8] 5.313 (3.477) n=14	[9] 4.861 (5.902) n=12
	No Training	[10] 5.453 (2.278) n=15	[11] 5.656 (2.817) n=12	[12] 4.698 (2.352) n=13

* $p < .10$

providing a rationally selected set with the effect of providing one example for difficult principles collapsed across training (Hypothesis 4a, $\Psi_1 = (\bar{x}_7 + \bar{x}_{10}) - (\bar{x}_8 + \bar{x}_{11})$. The comparison was not significant ($t = .5742$).

The second comparison compared the effect of providing a rationally selected set with the effect of providing one example for easy principles when instruction on concepts was given (Hypothesis 4b, $\Psi_2 = \bar{x}_1 - \bar{x}_2$). This comparison was also not significant ($t = -.7396$).

The final comparison contrasted the effect of providing a rationally selected set with the effect of providing one example for easy principles when instruction on concepts was given (Hypothesis 4_b ($\Psi_3 = \bar{x}_4 - \bar{x}_5$). This comparison was significant ($t = 2.3317$, $p < .05$).

It can be concluded on the basis of these three comparisons that providing a rationally selected set as compared to one example made little difference for difficult principles. However, there was a difference for easy principles, but only when no training on concepts was given as had been predicted.

Three other interactions of minor importance were found to be significant. They were sex by training on subconcepts, sex by type of principle, and sex by type of principle by mode of presentation.

Means for the sex by training interaction are presented in Table 16. Inspection of the means reveals that the interaction was caused primarily by the fact that females performed better without training than they did with training, while males performed better with training than they did without. The difference between the means for training and no training for females (.612) and the difference between the means for training and no training for males (.613) were almost identical.

Table 16.

Adjusted Means, Adjusted Variances, and Cell Sizes for Sex by Training Interaction**

Application Items

	Sex	
	Male	Female
Training	5.552 (4.327) n=40	5.059 (5.014) n=14
No Training	4.939 (3.709) n=38	5.671 (3.612) n=40

** $p < .05$

Means for the sex by type of principle interaction are given in Table 17. It is clear from the means that the interaction was due to the fact that females performed better on the easy principles than on the difficult principles while males performed better on the difficult principles than on the easy principles. This trend is apparent again in the sex by type of principle by mode of presentation interaction (Table 18). The three-way interaction appears to have been caused by differences in the ordering of the means within rows. In all cases except male-easy the ordering is set > one example > placebo. In the case of male-easy it is placebo > set > one example.

As with the knowledge items, effects due to all higher order interactions were pooled and tested as a residual sum of squares to remove their effect from the error variance. The regression due to the 4-way and 5-way interactions was found to be significant. However, as the higher order interactions were considered uninterpretable the cause of the significance was not investigated.

Relationship of the Covariate to the Dependent Measures

Regression analyses for knowledge and application items revealed that the effect of the covariate on the dependent variables was significant in both cases (knowledge items: $F_{1,110} = 17.800$, $p < .01$; application items: $F_{1,110} = 9.449$, $p < .01$). Therefore, a significant amount of variance on the dependent measures was removed by covariate adjustment. The correlation between the covariate and each of the two dependent measures was: knowledge items .44; application items .33. Apparently, the higher the subject's score on reading achievement the better the subject's performance on both dependent measures.

Table 17.

Adjusted Means, Adjusted Variances, and Cell Sizes for Sex by Type of Principle Interaction**

Application Items

	Sex	
	Male	Female
Easy Principle	4.811 (4.969) n=39	5.689 (4.958) n=40
Difficult Principle	5.696 (2.874) n=39	5.041 (3.679) n=41

** $p < .05$

Table 18.

Adjusted Means, Adjusted Variances, and Cell Sizes
for Sex by Type of Principle
by Mode of Presentation Interaction**

Application Items

		Mode of Presentation		
		Set	One Example	Placebo
Female	Easy Principle	6.582 (1.417) n=15	5.916 (2.234) n=13	4.326 (2.530) n=12
	Difficult Principle	5.317 (1.849) n=14	5.039 (1.851) n=14	4.745 (2.159) n=13
Male	Easy Principle	4.801 (2.356) n=13	4.520 (2.252) n=13	5.113 (2.219) n=13
	Difficult Principle	6.183 (1.493) n=15	5.975 (1.559) n=12	4.809 (1.842) n=12

** $p < .05$

Psychometric Characteristics of Tests

Hoyt internal consistency reliability estimates (Hoyt, 1941) were computed for each type of item (knowledge and application) on the four tests using the FORTAP Test Analysis Package (Baker, 1969). These reliabilities and the sample sizes upon which they are based are presented in Table 19.

The reliability estimates are lower than is desirable. Brown (1970) has listed several factors that can contribute to low reliabilities: range of individual differences, test difficulty, and length of test. Of these, certainly one of the principal factors contributing to low reliabilities in the present study is the test length. Each reliability estimate is based upon only eight items. High reliabilities (.85 and over) generally require tests of at least 40 items. An inspection of subjects' performance on individual items revealed that an additional factor contributing to the low reliabilities was test difficulty. Several of the items failed to discriminate properly among subjects. These items apparently were so easy that almost all subjects answered them correctly. Indeed, for the dependent measure with the lowest reliability (mathematics - easy - knowledge) half of the items were answered correctly by all subjects. Nevertheless, even relatively low reliability estimates can permit accurate conclusions concerning group means because reliabilities are based on individuals' performance which is in general more variable than that of group performance.

Table 19.

Hoyt Internal Reliability Estimates for Dependent Measures

Dependent Measures	Hoyt Reliability	Sample Size
Language Arts - Easy		
Knowledge	.65	39
Application	.78	39
Language Arts - Difficult		
Knowledge	.67	40
Application	.51	40
Mathematics - Easy		
Knowledge	.23	40
Application	.49	40
Mathematics - Difficult		
Knowledge	.59	40
Application	.39	40
Mean Reliability for Easy Principles		
Knowledge	.44	79
Application	.64	79
Mean Reliability for Difficult Principles		
Knowledge	.63	80
Application	.45	80

Chapter V

DISCUSSION AND CONCLUSIONS

This study was designed to investigate the effect of two instructional variables on the learning of principles. These variables were instruction on the concepts related in the principle, and number and type of instances used to illustrate the principle. It was predicted, based on previous results, that the effect of these variables would vary as a function of the particular combination of the variables presented and the difficulty of the principle being learned. Principles from two curriculum areas were used to increase the generality of the results. Sex was also included as a variable, primarily to reduce error variance.

Knowledge Items

Results obtained on knowledge items designed to test subjects' ability to recognize the statement of a principle and instances of its correct application were generally disappointing. There was no significant effect for instruction on concepts or for number and type of instances used to illustrate the principle. Indeed, even subjects presented with the statement of a principle and a rationally selected set of examples and nonexamples performed no better than control subjects. The predicted interaction between type of principle, training, and mode of presentation was also nonsignificant.

Two interactions based on knowledge item means were found to be significant. However, these interactions were not of central interest and specific hypotheses about them had not been formulated. The first was a subject matter by type of principle interaction. It was concluded on the basis of this interaction that after instruction the distinction between easy and difficult principles remined for mathematics principles but not for language arts principles. The second was a sex by type of principle by mode of presentation interaction. A meaningful interpretation of this three-way interaction is difficult to formulate. It was apparent that females tended to do better on easy principles than on difficult principles while males tended to do better on difficult principles than on easy principles. However, the two-way interaction between type of principle and sex was not significant so this interpretation cannot be considered entirely justifiable.

The lack of significance on knowledge items seems to have been due to a ceiling effect. The mean score across all conditions was 6.642 (83.0%), and as mentioned above, there was no significant difference between treatment and control groups. Perhaps a longer test of more than eight items or a test of more difficult items would have proved a more discriminable dependent measure. However, because of the high performance of control subjects the preferred explanation seems to be that subjects had some knowledge of the principles prior to experimentation.

Application Items

Results on application items in general supported the predictions of the study. There was a main effect for mode of presentation with all means in the predicted direction. Post-hoc comparisons, however,

revealed that only the group given a statement of the principle and a rationally selected set differed significantly from the control. Apparently, if the difficulty of a principle is not known or not considered to be relevant, a rationally selected set of instances should be presented when teaching a principle.

The interaction of interest between type of principle, training, and mode of presentation was found to be marginally significant for application items. An examination of the means for which specific hypotheses had been made revealed that for easy principles providing a rationally selected set of instances was significantly more effective than one example when subjects received instruction on concepts, but made no difference when subjects did not receive such instruction. This finding was in line with the predicted results. However, no differences were found between a rationally selected set and one example for difficult principles.

An important difference in teaching strategy is suggested by the significant main effect for mode of presentation and the training by type by mode of presentation interaction. This is that without instruction on the concepts related in a principle a rationally selected set should always be provided; however, with instruction on concepts one example alone may be equally effective if the principle to be learned is quite easy or simple.

Three other interactions for which specific hypotheses were not made were also found to be significant. All three included sex as a factor. The first was a sex by training interaction. It was caused by the fact that females performed better without training on concepts

than they did with training while males performed better with training than without. Possibly females had more difficulty remembering and integrating the material presented in the Subconcept-Training lessons than males did. The importance of the sex by training interaction and the factors contributing to the finding are questions to be answered by further research.

The remaining two interactions were sex by type of principle and sex by type of principle by mode of presentation. In general, the same conclusion can be drawn from these interactions as was drawn from the significant sex by type by mode of presentation interaction for knowledge items. Females seemed to do better on easy principles than on difficult principles while the reverse was true for males. Again, the importance of this finding is a question for further research.

General Considerations

The difference between results on knowledge items and application items can be explained in at least two ways. According to Gagné (1970), knowledge items as defined here do not serve as tests of attained principles; only questions requiring the application of principles are true tests of learning. Perhaps it is unrealistic to expect instructional conditions designed to facilitate the application of principles to also facilitate subjects' ability to recognize principle statements and correct applications. It may be that different processes are actually involved which require different kinds of instructional conditions.

A second explanation relates to the generally high level of performance on knowledge items. As indicated above, a ceiling effect

could have obliterated any real differences between treatments. It is important to note, however, that even though subjects performed uniformly on knowledge items the experimental treatments did result in differences on application items. It can be concluded from this that even when students have some prior knowledge of the principles to be taught instructional variables can affect their ability to apply the principles.

A surprising finding was the lack of significant main effects for instruction on subconcepts. This contradicts the ideas of Gagné (1970), Ausubel and Robinson (1969), and Klausmeier, Ghatala, and Frayer (1974). Possibly subjects were already familiar with the concepts, or the deliberate absence of integration between Subconcept-Training and Principle-Training lessons rendered the information presented on the concepts difficult to utilize. Another explanation is suggested by the significant sex by training interaction on application items. It may be that males in general would profit more than females from prior instruction on concepts related in a principle.

One of the minor questions of the study which deserves some discussion concerns the two types of control groups employed. One control read Subconcept-Training lessons and then placebo material while the other control read only placebo material. It was suggested that possibly the control group reading Subconcept-Training lessons would arrive at the principle inductively and perform better on the dependent measures than the other control group. This does not appear to have occurred. Although there was no significant interaction for training by mode of presentation inspection of the control group means reveals that the two groups performed similarly on knowledge and application

items (knowledge: control 1 - mean = 6.602, control 2 - mean = 6.102; application: control 1 - mean = 4.606, control 2 - mean = 4.894).

A final consideration concerns the way in which "difficult" and "easy" principles were defined. Results from both knowledge items and application items lead to the conclusion that the easier principles for females were not the easier principles for males. How this relates to the finding of a training by type by mode of presentation interaction is unclear. The more important point, however, is that the terms "easy" and "difficult" should be operationally defined in terms of the particular group for which instruction is intended. In this way student knowledge as well as any sex differences could be noted precisely for the designated population. It would be a relatively easy task for a researcher or teacher to pretest a subsample of the target population on the principles of interest to gain this information.

Suggestions for Further Research

Additional research to clarify the nature and importance of the significant interactions involving sex has already been suggested. The more important area for further research, however, is the area of central concern in the present study: the effect of the kind and the amount of instruction provided on principle learning. Further research could focus on such questions as whether the effectiveness of a rationally selected set of examples and nonexamples is due to the variety of the instances or simply to the number of instances, and whether instruction on concepts related in a principle that is designed to integrate the concepts with one another as they are taught (possibly by teaching the principle and the concepts simultaneously) would be more facilitative than the type of instruction provided in the present study.

Conclusions

The following major conclusions can be drawn from the results of the present study:

1. In general, providing a rationally selected set of examples and nonexamples of a principle is more facilitative than providing one example.
2. For very simple or easy principles a rationally selected set of examples and nonexamples is equally as effective as one example if preinstruction on concepts is given, but is significantly more effective than one example if no preinstruction is given.
3. Even when students are able to identify the statement and correct applications of a principle instruction involving training on subconcepts and examples of correct and incorrect applications of the principle can facilitate the students' ability to apply the principle.

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(Part 2 of 2 Parts)

instructional factors relating to children's principle learning

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WISCONSIN RESEARCH
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INSTRUCTIONAL FACTORS RELATING TO CHILDREN'S PRINCIPLE LEARNING

by Katherine Vorwerk Feldman

Report from the Project on Conditions of School Learning and Instructional Strategies

Herbert J. Klausmeier
Principal Investigator

Wisconsin Research and Development
Center for Cognitive Learning
The University of Wisconsin
Madison, Wisconsin

August 1974

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ABSTRACT

The present study investigated the effect of two external conditions on the learning of principles by children. The external conditions were instruction on the major concepts related in the principle and the number of teaching examples (correct applications) and teaching nonexamples (incorrect applications) of the principle presented with a statement of the principle.

Subjects were 159 fifth-grade students of average ability and socioeconomic status. Two principles from each of two subject matters (mathematics and language arts) served as the content of the learning task. One principle from each subject matter was designated as "easy" and one as "difficult" on the basis of previous research.

The principles were presented in printed, self-instructional lesson booklets. Several versions of the booklets were prepared in which the instructional variables of interest were systematically varied. Variations in the type of lessons read by the subjects constituted the experimental conditions. Mastery of the principles was determined by tests designed to assess subjects' knowledge of and ability to apply the principles.

In general a rationally selected set of examples and nonexamples was found to be more facilitative than one example, although it was concluded that for easy principles providing one example was equally effective as a rationally selected set when instruction on concepts related in the principle was also provided. Main effects for instruction on concepts related in the principles were not found to be significant; the conditions associated with this unanticipated result were discussed.

APPENDIX A

CONCEPT ANALYSES FOR SUBCONCEPTS

Noun

Definition: A word that is the name of a person, place, or thing.

Relevant attributes:
1. word
2. functions as the name of something (person, place, or thing)

Irrelevant attributes:
1. number of syllables in word
2. initial letter of word
(3. whether capitalized or not)

Rational Set:
1. Examples:
   - Tom
   - beauty
   - India
2. Nonexamples:
   - tall
   - barked
   - immediately

Capitalize

Definition: Word that means to write the first letter of a word in capital letters.

Relevant attributes:

1. word
2. means to write the first letter of a word in capital letters

Irrelevant attributes:

1. the type of word that is capitalized (i.e., length, part of speech)
2. position in a sentence of the capitalized word

Examples:

Before

Him

Silently

Nonexamples:

below

her

slowly

Proper Noun

Definition: Noun that names a particular person, place, or thing.

Relevant attributes:
1. noun
2. names a particular person, place, or thing

Irrelevant attributes:
1. irrelevant attributes associated with noun

Rational Set:
1. Examples:
   - Rags
   - Paris
   - Jane
2. Nonexamples:
   - city
   - girl
   - hill

Common Noun

Definition: Noun that names more than one person, place, or thing

Relevant attributes:
1. noun
2. names more than one person, place, or thing

Irrelevant attributes: irrelevant attributes associated with noun

Rational set:
1. Examples:
   - money
   - state
   - doctor
2. Nonexamples:
   - President Nixon
   - Baraboo
   - Fritos

Plural

Definition: A word that is used to show that only one of something is meant.

Relevant attributes:
1. word
2. indicates that more than one of something is meant

Irrelevant attributes:
1. what the plural thing (noun) is (i.e., person, place, thing)
2. irrelevant attributes associated with noun
3. how the plural form is formed

Rational set:

1. Examples:

cats	schools
boxes	houses
bottles	mice

2. Nonexamples:

girl

mother

Singular

Definition: A word that is used to show that only one of something is meant.

Relevant attributes:
1. word
2. indicates that only one of something is meant

Irrelevant attributes:
1. what the singular thing (noun) is (i.e., person, place, thing)
2. irrelevant attributes associated with noun

Rational set:
1. Examples:

girl	school
box	house
bottle	mouse

2. Nonexamples:

horses

Angle

Definition: The shape made by two straight lines meeting in a point.

Relevant attributes:

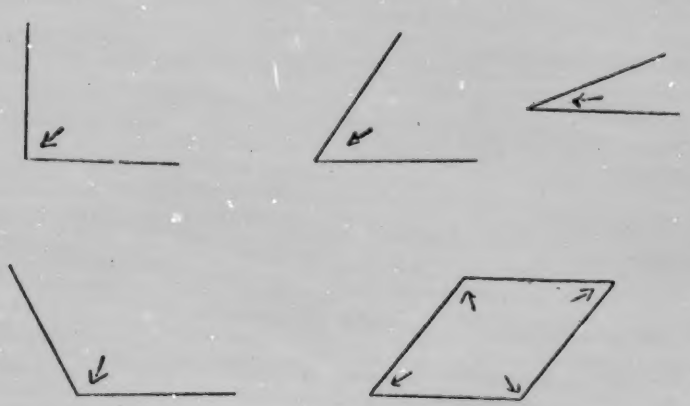
1. shape
2. made by two lines
3. lines must be straight
4. lines must meet

Irrelevant attributes:

1. size of angle
2. length of lines
3. whether part of a closed figure
4. spatial orientation

Rational Set:

1. Examples



2. Nonexamples

Side

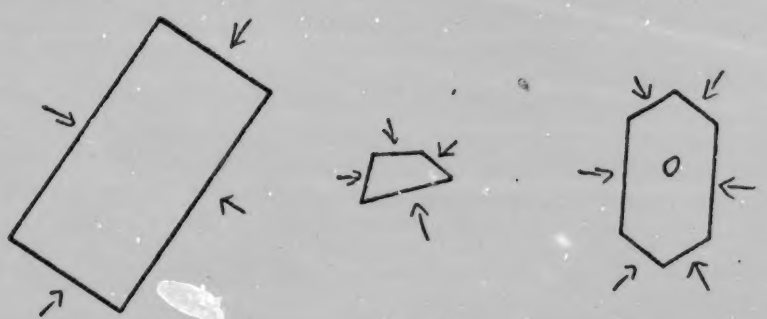
Definition: Any of the outside lines of a figure.

Relevant attributes:
1. outside lines of a figure
2. (any)

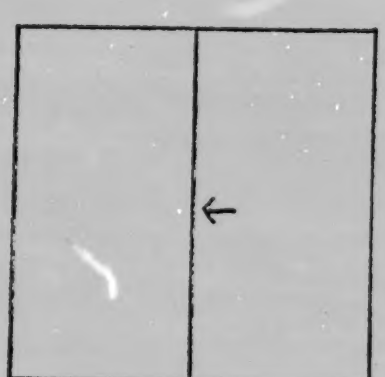
Irrelevant attributes:
1. number of sides
2. type of figure
3. size of lines (figure)
4. orientation

Rational Set:

1. Examples:



2. Nonexample



Triangle

Definition: A figure with three straight sides. It also has three angles.

Relevant attributes:
1. figure
2. three sides
3. straight sides
4. three angles

Irrelevant attributes:
1. size
2. spatial orientation

Rational Set:

1. Examples:

2. Nonexamples

Equilateral

Definition: A word that means having all sides equal.

equi means equal

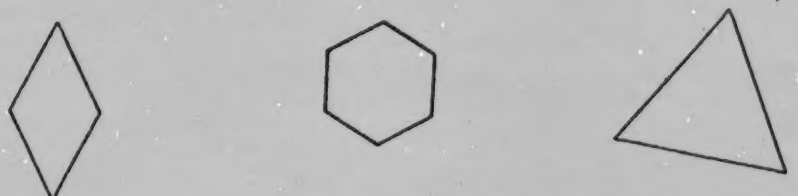
lateral means side

Relevant attributes:
1. a word
2. means sides are same length

Irrelevant attributes:
1. size of figure
2. spatial orientation
3. number of sides

Rational Set:

1. Examples:



2. Nonexamples

Similar

Definition: A word that means figures have the same shape although they may differ in other ways (i.e., size, orientation).

Relevant attributes:

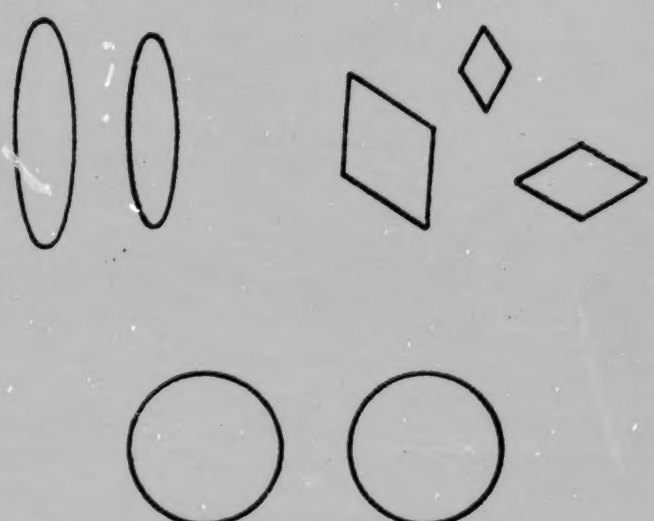
1. word
2. means figures have same shape
3. figures may differ in other ways (distinguishes similar from identical)

Irrelevant attributes:

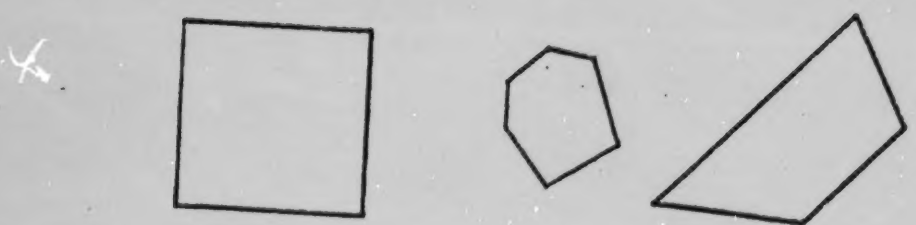
1. size of the figures
2. orientation of the figures

Rational Set:

1. Examples:



2. Nonexamples



APPENDIX B

SUBCONCEPT-TRAINING LESSONS

LESSON S-NE

Name_____

Date_____

Teacher_____

School_____ Grade_____

Circle One: GIRL BOY

WORD LIST

1. capitalize
2. perennial
3. triangle
4. proper
5. singular
6. similar
7. common
8. equilateral
9. plural
10. degrees
11. particular
12. angle

This lesson is about three words. You may already know something about these words, or they may be new to you. Your job is to read the information about each word carefully and to try to learn it.

These are the three words you will read about in this lesson:

1.) PLURAL

2.) SINGULAR

3.) NOUN

PLURAL

Let's begin with the word plural. Read the information in the box below. It tells you what plural means.

Plural is a word that is used to show that more than one of something is meant.

For example, if I asked you to write the plural form of the word cat, you would write the word cats. The word cats means more than one cat.

Here is another example. If I asked you to write the plural form of the word box, you would write the word boxes. You would know when I said plural, I meant that you should write the word that means more than one box.

Here are some other plural forms of words. Eash one shows that more than one of something is meant:

bottles

schools

houses

mice

Now, to help you really understand what plural means, read this page.

Suppose I asked you to write the plural form of the word mothers. Would you be able to do it? No! The word mothers is already plural. It already means more than one mother.

Now suppose I said that the plural form of the word girl is girl. Would this be true? No! Plural means that more than one is meant. The plural form of girl is girls.

SINGULAR

Carefully read the information in the box below. It tells you what singular means.

> Singular is a word that is used to show that only one of something is meant.

Singular is the opposite of plural. Singular means that only one of something is meant. Plural means that more than one of something is meant.

So if I asked you to write the singular form of the word girls, you would write girl. And if I asked for the singular form of the word boxes, you would write box.

Here are the singular forms of the words on page 3. Each one shows that only one of something is meant:

bottle

school

house

mouse

Now, suppose I asked you to write the singular form of the word horses and you wrote the word horses. Would you be right? No, you would be wrong. Singular means that only one of something is meant. The singular form of the word horses is the word horse.

NOUN

Now you are going to learn what the word noun means. Read the information in the box below.

A noun is a word that is the name of a person, place, or thing.

The important thing to remember about a noun is that is names something. So any name is a noun.

Look carefully at the nouns below. Each one is the name of something.

TOM BEAUTY INDIA

TOM is the name of a person.

BEAUTY is the name of a thing.

INDIA is the name of a place.

Now look at these words. They are not nouns. Do you know why?

TALL BARKED IMMEDIATELY

These words are not nouns because they do not name a person, place, or thing.

Now test yourself and see what you have learned. Answer the questions below. If you are not sure of an answer, you may turn back to find out what it is.

1. Draw a circle around all the plural forms of words below.

geese jungles toe

2. Draw a circle around all the singular forms of words below.

fathers home truck countries

3. Draw a circle around the nouns below.

PEANUT RUN UNTIL NAIL

Here are the right answers.

1. Draw a circle around all plural forms of words below.

geese jungles toe

2. Draw a circle around all the singular forms of words below.

fathers home truck countries

3. Draw a circle around the nouns below.

PEANUT RUN UNTIL NAIL

Lesson S-ND

Name_____

Date_____

Teacher_____

School_____ Grade_____

Circle One: GIRL BOY

WORD LIST

1. capitalize
2. perennial
3. triangle
4. proper
5. singular
6. similar
7. common
8. equilateral
9. plural
10. degrees
11. particular
12. angle

This lesson is about two words. You may already know something about these words, or they may be new to you. Your job is to read the information about each word carefully and to try to learn it.

These are the two words you will read about in this lesson:

1.) NOUN

2.) CAPITALIZED

NOUN

Let's begin with the word noun. Read the information in the box below. It tells you exactly what the word noun means.

> A noun is a word that is the name of a person, place, or thing.

The important thing to remember about a noun is that it names something. So any name is a noun.

Look carefully at these words. They are all nouns. Each one is the name of something.

TOM BEAUTY INDIA

TOM is the name of a person.

BEAUTY is the name of a thing.

INDIA is the name of a place.

Now look at these words. They are not nouns. Do you know why?

TALL BARKED IMMEDIATELY

These words are not nouns because they do not name a person, place, or thing.

There are two kinds of nouns. There are proper nouns and there are common nouns.

A noun is a proper noun if it names one particular person, place, or thing. For example, your name is a proper noun. It names you. Here are some other proper nouns. They are underlined in the sentences below. Each one names a particular person, place or thing.

My dog RAGS is happy.
(RAGS is the name for a particular dog.)

I live in PARIS.
(PARIS is the name of a particular place.)

Come here, JANE.
(JANE is the name of a particular person.)

Here are some other proper nouns. Read each one carefully

PRESIDENT NIXON BARABOO FRITOS

A noun is a common noun if it can be used to name more than one person, place, or thing. For example, the word DOG can be used to name any dog. It is a common noun.

Here are some other common nouns. They are underlined in the sentences below.

A CITY can be dangerous.

I am a GIRL.

I will climb the HILL.

Here are some other common nouns. Read each one carefully.

MONEY STATE DOCTOR

CAPITALIZE

Now read about the word capitalize in the box below.

Capitalize means to write the first letter of a word in capital letters.

Look at the words below. Each one is capitalized.

Before

Him

Silently

The first letter of each of these words is a capital letter. So these words are capitalized.

Now look at these words. The first letter of each of these words is not a capital letter. So these words are not capitalized.

below

her

slowly

Now test yourself and see what you have learned. Answer the questions below. If you are not sure of an answer, you may turn back to find out what it is.

1. Draw a circle around the nouns below.

PEANUT RUN UNTIL NAIL

2. Draw a circle around the proper nouns below.

TEACHER MISSISSIPPI CATS CAROL

3. Draw a circle around the capitalized words.

subject New Freedom wall Airplane

Here are the right answers.

1. Draw a circle around the nouns below.

PEANUT RUN UNTIL NAIL

2. Draw a circle around the proper nouns below.

TEACHER MISSISSIPPI CATS CAROL

3. Draw a circle around the capitalized words.

subject New Freedom wall Airplane

LESSON S-EE

Name_____

Date_____

Teacher_____

School_____ Grade____

Circle One: GIRL BOY

WORD LIST

1. capitalize
2. perennial
3. triangle
4. proper
5. singular
6. similar
7. common
8. equilateral
9. plural
10. degrees
11. particular
12. angle

This lesson is about three words. You may already know something about these words, or they may be new to you. Your job is to read the information about each word carefully and to try to learn it.

These are the three words you will read about in this lesson.

1.) ANGLE

2.) SIDE

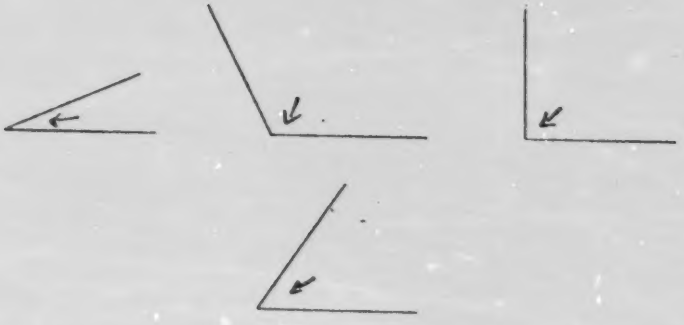
3.) TRIANGLE

ANGLE

Let's begin with the word angle. Read the information in the box below. It tells you exactly what the word angle means.

An angle is the shape made by two straight lines meeting in a point.

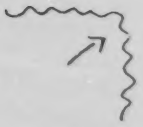
Now look at the figures below. They show four different angles.



The arrows are pointing at the angles.

Now look at these two figures. They are not angles. Do you see why? Read on and find out.

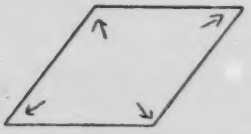
This is not an angle because the lines do not meet in a point.



This is not an angle because the lines are not straight.

Now look at these figures. You can see that their sides meet in a point to make angles. The arrows are pointing at the angles. Each figure has a different number of angles.

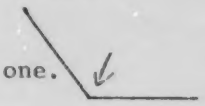
This figure has <u>three</u> angles.



This figure has <u>four</u> angles.

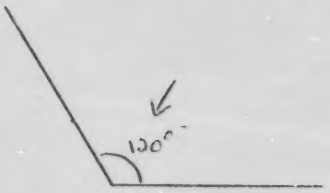
This figure has <u>six</u> angles.

Not all angles are the same size.

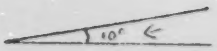
Some angles are big, like this one. 

Some angles are small, like this one.

The size of an angle is measured in <u>degrees</u>. Big angles are many degrees. Small angles are only a few degrees. Look at these examples.



The angle the arrow is pointing at is 120 degrees. For 120 degrees we can write 120°.



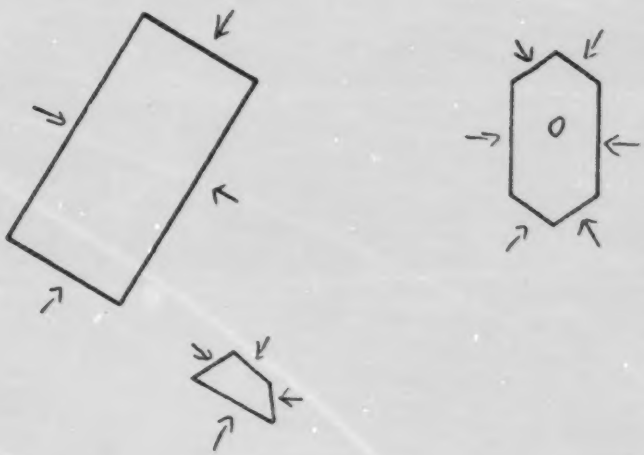
The angle the arrow is pointing at is 10 degrees. For 10 degrees we can write 10°.

SIDE

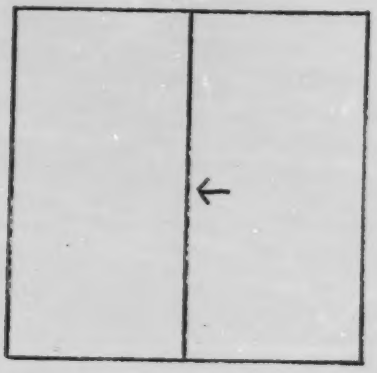
The next word you are going to learn about is side. You probably think you know what side means. But here we want you to learn a special meaning for the word side. We want you to learn what the side of a figure is. So read the definition in the box below.

Side - any of the outside lines of a figure.

To help you understand what the information in the box means, look at these figures. The arrows point to their sides.



Now look at this figure. The arrow is not pointing to a side. It is pointing to a line inside the figure. Remember, only the outside lines of a figure are its sides.



The arrow is not pointing to a side.

Sometimes the sides of a figure are the same length. For example, look at the figures below.

The sides of these figures are all the same length. You may measure the sides yourself to be sure.

Sometimes the sides of figures are not the same length. Look at these figures.

The sides of these figures are not all the same length. Measure yourself to be sure.

TRIANGLE

Now you are going to learn about the word triangle. Read the definition in the box below. It tells you what a triangle is.

> A triangle is a figure with three straight sides. It also has three angles.

Now look at these examples of triangles.

These triangles are different sizes. And they are all pointed in different directions. But they are all triangles. They all have three straight sides and three angles.

Now to help you really understand what a triangle is, look at these figures. They are not triangles.

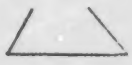
This figure is not a triangle because it has more than three straight sides and more than three angles. It has four straight sides and four angles.

Now look at this figure. It is not a triangle either. Can you see why? It has only two straight sides and one angle.

Now test yourself and see what you have learned.

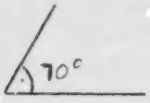
Answer the questions below. If you are not sure of an answer, you may turn back to find out what it is.

1. How many angles does this figure have?



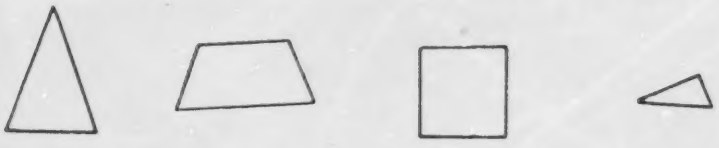
_____

2. This angle is _____degrees.



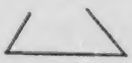
3. How many sides does this figure have? _____

4. Draw a circle around the triangles below.

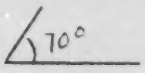


Here are the right answers.

1. How many angles does this figure have? 2

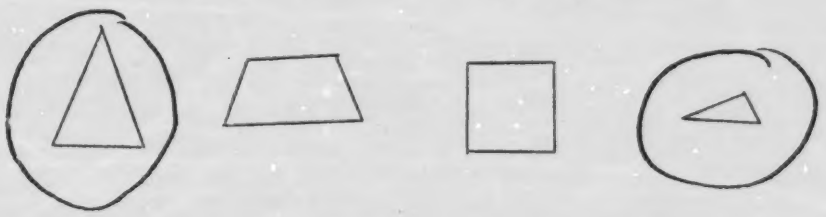


2. This angle is 70 degrees.



3. How many sides does this figure have? 3

4. Draw a circle around the triangles below.



LESSON S-ED

Name_____

Date_____

Teacher_____

School_____ Grade_____

Circle One: GIRL BOY

WORD LIST

1. capitalize
2. perennial
3. triangle
4. proper
5. singular
6. similar
7. common
8. equilateral
9. plural
10. degrees
11. particular
12. angle

This lesson is about four words. You may already know something about these words, or they may be new to you. Your job is to read the information about each word carefully and to try to learn it.

These are the four words you will read about in this lesson:

1.) SHAPE

2.) SIMILAR

3.) TRIANGLE

4.) EQUILATERAL

SHAPE

Let's begin with the word shape. Read the information in the box below. It tells you exactly what the word shape means.

Shape - the way a thing looks because of its outline.

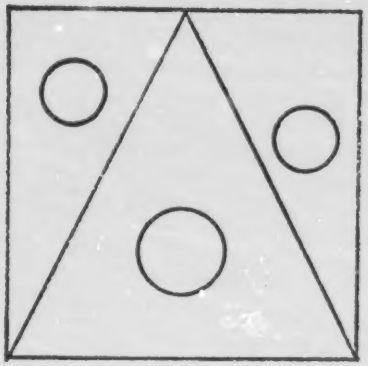
Now look at the figures below.

The shape of this figure is a butterfly because it looks like a butterfly.

The shape of this figure is long and thin because it looks long and thin.

The shape of this figure is round, (or a circle) because it looks round.

Remember, it is the outline of a figure that decides what shape it is. For example, look at the figure below.



This figure has several shapes inside it. But the shape of the whole figure is a square. Remember, only the outline of a figure decides what shape it is.

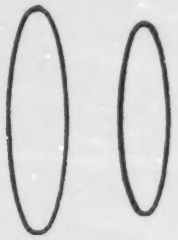
SIMILAR

Now read about the word similar in the box below.

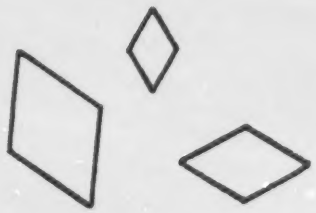
> If things are similar, it means that they have the same shape. But they may be different in other ways.

For example, similar figures have the same shape. But they do not have to be the same size. And they do not have to be "pointed" in the same direction. Similar figures are almost, but not exactly, the same.

To help you understand what similar means, look at the examples below.



These two figures are similar. They are the same shape, but one is larger than the other. So they are almost, but not exactly, the same.

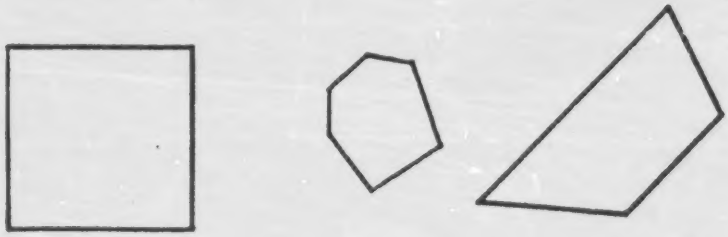


Next look at these figures. They are similar too. They are all the same shape. But some are bigger than others, and they are all pointed in different directions. They are almost, but not exactly, the same. They are similar.

These figures are similar.

Sometimes when two things look exactly alike, like the two figures on the left, they are also called similar.

Now to help you really understand, look at these figures. They are not similar. Each one is a different shape.



Next look at these figures. They are not similar either. Each one is a different shape.

Remember, if things are similar, it means that they have the same shape.

TRIANGLE

Now you are going to learn about the word triangle. Read the definition in the box below. It tells you what a triangle is.

> A triangle is a figure with three straight sides.
> It also has three angles.

Now look at these examples of triangles.

These triangles are different sizes. And they are all pointed in different directions. But they are all triangles. They all have three straight sides and three angles.

Now to help you really understand what a triangle is, look at these figures. They are not triangles.

This figure is not a triangle because it has more than three straight sides and more than three angles. It has four straight sides and four angles.

Now look at this figure. It is not a triangle either. Can you see why? It has only two straight sides and one angle.

EQUILATERAL

Now you are going to learn what the word equilateral means. Read the information in the box below.

Equilateral means having all sides equal.
equi means equal
lateral means side

Look at these figures. They are all equilateral because their sides are all the same length. You may measure the sides yourself to check if you like.

Now look at this figure. It is not equilateral. Its sides are different lengths. Measure and see for yourself.

Let's put the words equilateral and triangle together. We get <u>equilateral triangle.</u> Do you know what an equilateral triangle is? It is a triangle with three equal sides. Look at the figures below.

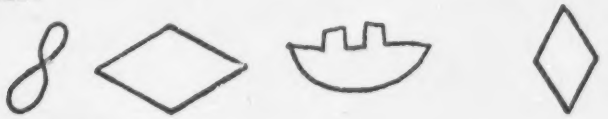
These are all equilateral triangles. The sides of each triangle are the same length.

Now look at this triangle. It is not equilateral. Its sides are not the same length.

Now test yourself and see what you have learned. Answer the questions below. If you are not sure of an answer, you may turn back to find what it is.

1. The shape of this figure is a _____

2. Draw a circle around the two figures below that are similar.

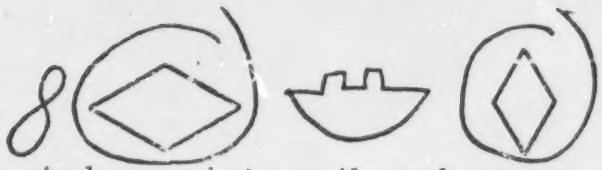


3. Draw a circle around the equilateral triangles below.

Here are the right answers.

1. The shape of this figure is a star.

2. Draw a circle around the two figures below that are similar.



3. Draw a circle around the equilateral triangle below.

APPENDIX C

PRINCIPLE ANALYSES

Language Arts - Easy Principle

Statement of principle: A singular noun names one person, place, or thing. A plural noun names more than one person, place, or thing.

Subconcepts:

1. noun
2. singular
3. names
4. one
5. person, place, thing
6. plural
7. more than one

Relevant attributes:

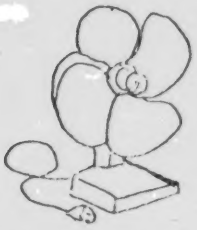
1. a) singular noun
   b) names one person, place, or thing
2. a) plural noun
   b) names more than one person, place, or thing

Irrelevant attributes:

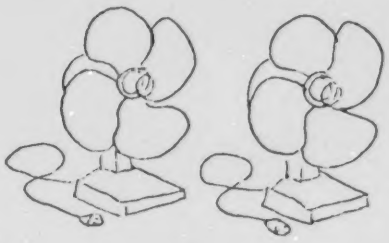
1. irrelevant attributes of noun
2. whether person, place, or thing is named and irrelevant attributes associated with each of those
3. how plural of noun is formed
4. how many persons, places, or things are named by plural noun

Rationally selected set of examples and nonexamples:

1) Examples



a <u>fan</u>

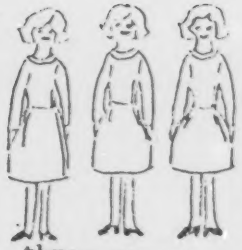


two <u>fans</u>

Washington, D.C. is a <u>city</u> in the United States

Washington, D.C., Madison, and New York are <u>cities</u> in the United States.

one <u>woman</u>



three <u>women</u>

2) Nonexamples

<u>one mice</u>

Rhine River

Mississippi River

Nile River

<u>three river</u>

Problem solving situations:

1) In which group of words should an s or an es be added to each word to make it plural? Circle the letter in front of the correct answer.

   a. children, friend, table
   b. ball, mice, pencil
   c. day, shoe, geese
   d. glass, coat, committee
   e. I don't know.

2) Look at the list of words below. some of them are plural nouns. Some of them are singular nouns. Draw a circle around all of the plural nouns.

   class

   calves

   men

   bed

Language Arts - Difficult Principle

Statement of principle: A proper noun is capitalized. A common noun is not capitalized.

Subconcepts:
1. noun
2. proper noun
3. capitalized
4. common noun

Relevant attributes:
1. a) proper noun
   b) capitalized
2. a) common noun
   b) not capitalized

Irrelevant attributes:
1. irrelevant attributes of noun
2. whether person, place, or thing is named and irrelevant attributes associated with each of those
3. position of noun in sentence
4. whether noun is singular or plural

Rationally selected set of examples and nonexamples:

1) Examples: That girl is named Kathy.
The largest states are Alaska and Texas.
The smallest planet, Mars, looks red.

2) Nonexamples: I have three Dogs.
I live in madison, the state capitol.

Problem solving situations:

1) In which group of words should every word be capitalized? Circle the letter in front of the correct answer.

a. monkey, dog, nevada
b. mother, father, hope
c. africa, larry, milwaukee
d. fire, war, peace
e. I don't know.

2) Look at the list of nonsense words below. Pretend that they are nouns. Some are common nouns. Some are proper nouns. Draw a circle around all of the common nouns.

dax

Tas

Boz

guk

Mathematics - Easy Principle

Statement of principle: If the three angles of a triangle are equal in number of degrees, the sides of the triangle are equal in length.

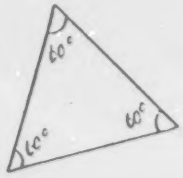
Subconcepts:
1. angles (three)
2. triangle
3. equal angles
4. number of degrees (of an angle)
5. sides
6. equal length sides

Relevant attributes:
1. three equal angles
2. three sides of equal length

Irrelevant attributes:
1. irrelevant attributes of equilateral triangle
2. the way the sides of the angles is determined
3. the way the length of the sides is measured

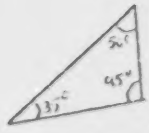
Rationally selected set of examples and nonexamples:

1) Examples



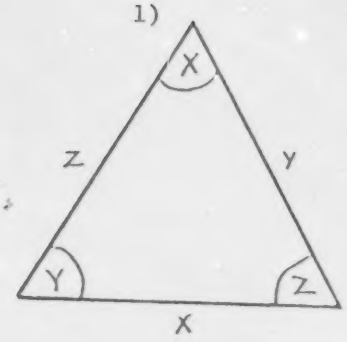
angle a = angle b = angle c

2) Nonexamples



Problem solving situations:

1)



Angles X, Y, and Z have exactly the same number of degrees. Suppose that side y is 2 inches long. How long is side x? Circle the letter in front of the correct answer.

a. 1 inch

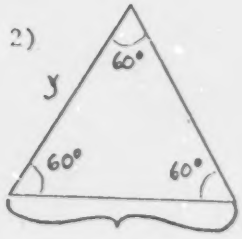
b. 2 inches

c. 3 inches

d. It is impossible to tell without measuring.

e. I don't know.

2)



1 inch

Look at the triangle on the left. How long is side y?

Circle the letter in front of the correct answer.

a. 1 inch

b. 2 inches

c. it is impossible to tell without measuring.

d. I don't know.

Mathematics - Difficult Principle

Statement of principle: All equilateral triangles are similar in shape.

Subconcepts:
1. all
2. triangles
3. equilateral triangles
4. similar in shape

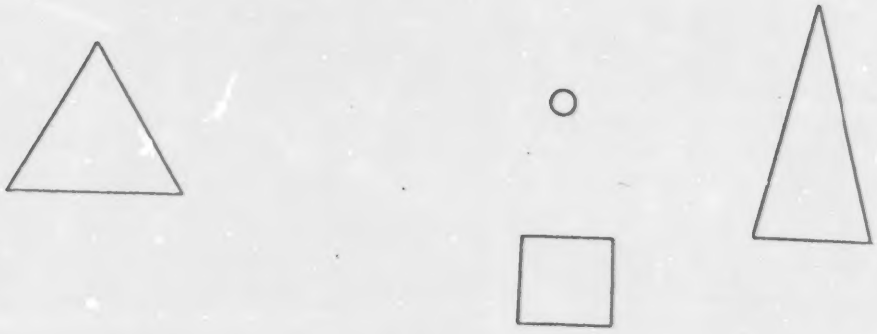
Relevant attributes:
1. (all) equilateral triangles
2. similar in shape

Irrelevant attributes:
1. irrelevant attributes of equilateral triangles
2. spatial orientation of similar equilateral triangles
3. sizes of similar equilateral triangles
4. number of similar equilateral triangles in an array

Rationally selected set of examples and nonexamples:

1) Examples

2) Nonexamples



Problem solving situations:

1)

Look carefully at these figures. Are they similar in shape? Circle the letter in front of the correct answer.

a. It is impossible to tell without measuring.

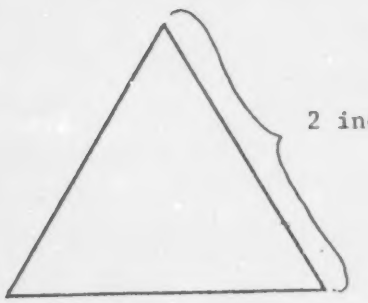
b. No, only some of them are similar in shape.

c. Yes, they are all similar in shape.

d. No, they are all different sizes.

e. I don't know.

2)



One side of this equilateral triangle is 2 inches long. Suppose that there was a second triangle that was similar to this one. How long would one side of the similar triangle be?

Circle the letter in front of the correct answer.

a. 1 inch

b. 2 inches

c. 3 inches

d. It is impossible to tell without measuring

e. I don't know.

APPENDIX D

PRINCIPLE-TRAINING LESSONS

2

Lesson NERS

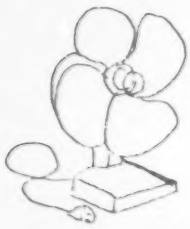
Name_____

Now you are going to learn an important fact about nouns. Here it is:

> A singular noun names one person, place, or thing. A plural noun names more than one person, place, or thing.

Read the fact in the box once more. Now look at the figures below.

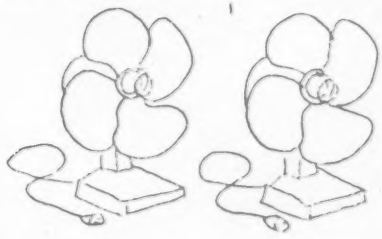
1.



a fan

The word fan is a singular noun. It names only one thing, the drawing above.

2.



two fans

The word fans is a plural noun. It names more than one thing. It names both of the drawings above.

Now look at these examples.

Washington, D.C. is a city in the United States

In the sentence above the word city is a singular noun. It names only one place, Washington, D.C.

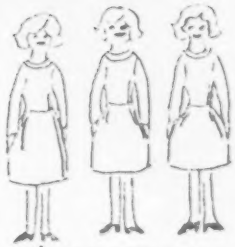
Washington, D.C., Madison, and New York are
cities in the United States.

In this sentence the word cities is a plural noun. It names three places, Washington, D.C., Madison, and New York.

one <u>woman</u>

Finally, look at these figures.

The word <u>woman</u> is a singular noun. It names only one thing, the figure on the left.



three <u>women</u>

The word <u>women</u> is a plural noun. It names more than one thing. It names all three figures on the left.

Now to help you really understand the fact on page 1 (turn back and read it again if you can't remember what it is), read the information below.

Is this a mice? No! It is a mouse. Mice is a plural noun. It should not be used to name the one animal above.

Rhine River

Mississippi River

Nile River

Are these things together called a river? No, they are called rivers. There are three of them. They should be named by a plural noun. River is a singular noun. Rivers is a plural noun.

Go back and read the fact in the box on page 1 again. Then read this lesson again carefully. Make sure you understand what the fact on page 1 means.

2

Lesson NDRS

Name_____

Now you are going to learn an important fact about nouns. Here it is:

> A proper noun is capitalized.
> A common noun is not capitalized.

Read the fact in the box once more. Now look at the sentence below. It contains one proper noun and one common noun. The proper noun is capitalized. It is the word Kathy. The common noun is not capitalized. It is the word girl.

That girl is named Kathy.

Next look carefully at this sentence.

The largest states are Alaska and Texas.

This sentence contains two proper nouns and one common noun. The proper nouns are capitalized. They are the words Alaska and Texas. The common noun is not capitalized. It is the word state.

Finally, look at this sentence. It has one proper noun and one common noun. The proper noun is the word Mars, and it is capitalized. The common noun is the word planet, and it is not capitalized.

The smallest planet, Mars, looks red.

Now to really help you understand the fact on page 1 (turn back and read it again if you can't remember what it is), look at these sentences.

I have three Dogs.

Can you see what is wrong with this sentence? The common noun is capitalized. It is the word dogs. It should not be capitalized.

I live in madison, the state capitol.

Can you see what is wrong with this sentence? The proper noun is not capitalized. It is the word Madison. It should be capitalized.

Go back and read the fact in the box on page 1 again. Then read this lesson again carefully. Make sure you understand what the fact on page 1 means.

2

Lesson EERS

Name_____

Now you are going to learn an important fact about triangles. Here it is:

> If the three angles of a triangle are equal in number of degrees, the sides of the triangle are equal in length.

Read the fact in the box once more. Now look at the triangle below.

The angles of this triangle, labeled x, y, and z are all equal in number of degrees. So the sides of the triangle are equal in length. If you like you may measure the sides of the triangle yourself to check that they are all the same length.

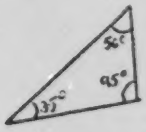
Next look carefully at this triangle. The angles of this triangle are also equal. They are all 60°.

Because the angles of this triangle are equal in number of degrees, the sides are equal in length. Check if you like.

Finally, look at this triangle. Its angles are also equal in number of degrees, so its sides are equal in length.

angle a = angle b = angle c

Now to really help you understand the fact on page 1 (turn back and read it again if you can't remember what it is), look at these two triangles.



All of the angles of this triangle are different sizes. So the sides of the triangle are not equal in length. Measure and see for yourself.

Now look at this triangle. Angle a is equal in size to angle b. But angle c is not equal to angle a and angle b. So the sides of the triangle are not all equal in length. Measure and see for yourself.

Go back and read the fact in the box on page 1 again. Then read this lesson again carefully. Make sure you understand what the fact on page 1 means.

2

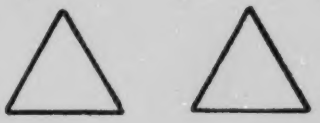
Lesson EDRS

Name _____

Now you are going to learn an important fact about equilateral triangles. Here it is:

All equilateral triangles are similar in shape.

Read the fact in the box once more. Now look at the equilateral triangles below.



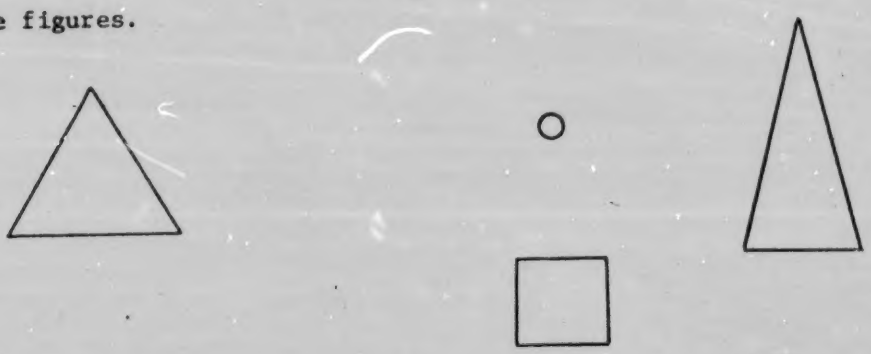
It is easy to see that these equilateral triangles are similar in shape.

Look carefully at these equilateral triangles. They are also similar in shape.

Next look at these equilateral triangles.

These equilateral triangles are similar in shape too.

Now to help you really understand the fact on page 1 (turn back and read it again if you can't remember what it is), look at these figures.



The figure on the left is an equilateral triangle . The figures on the right are not equilateral triangles. It is easy to see that the figures on the right and the equilateral triangle on the left are not similar in shape.

Go back and read the fact in the box on page 1 again. Then read this lesson again carefully. Make sure you understand what the fact on page 1 means.

APPENDIX E

TESTS

Test NE

Name_____

In this booklet you will be asked to answer some questions. Sometimes you will be asked to circle the correct answer to a question. Sometimes you will be asked to circle a letter in front of the correct answer. Here are some examples.

Example A

Look at the sentence below. If the sentence is correct, circle the word YES. If the sentence is not correct, circle the word NO.

All boys are also girls. YES (NO)

The sentence is not correct so the word NO is circled.

Example B

How many minutes are there in one hour? Circle the letter in front of the correct answer.

a. 10 minutes
(b.) 60 minutes
c. 90 minutes
d. 120 minutes
e. I don't know

The correct answer is 60 minutes so the letter "b" is circled.

Example C

Look at the drawings below. Draw a circle around the ones that are pictures of living things.

The moose and the bird are alive so they are circled.

General Instructions: Read each question carefully. Then choose the best answer. Make sure you answer every question. Do not skip questions. When you have finished one page, go on to the next. Do not turn back to pages you have finished. If you have any questions, raise your hand.

Directions: Look at the sentences below. If the sentence is correct, circle the word YES. If the sentence is not correct, circle the word NO.

1. The word friends is a plural noun. YES NO

2. The word triangle is a plural noun. YES NO

3. The word mass is a plural noun. YES NO

4. The word oxen is a plural noun. YES NO

5. The word side is a plural noun. YES NO

6. The word ladies is a plural noun. YES NO

See the sentence below with the two words underlined.

"That school has many windows."

In the sentence above, the word school

(Circle the letter in front of the correct answer.)

a. names one person, place, or thing

b. names many persons, places, or things

c. names a particular action

d. names many particular actions

e. I don't know.

See the sentence below with the two words underlined.

"That school has many windows."

In the sentence above, the word windows

(Circle the letter in front of the correct answer.)

a. names a particular action

b. names many particular actions

c. names one person, place, or thing

d. names many persons, places, or things

e. I don't know.

In which group of words should an s or an es be added to each word to make it plural? Circle the letter in front of the correct answer.

a. bushes, fly, enemies

b. knife, loaves, radios

c. boy, book, dress

d. monkeys, pianos, shelf

e. I don't know.

In which group of words should an s or an es be added to each word to make it plural? Circle the letter in front of the correct answer.

a. children, friend, table

b. ball, mice, pencil

c. day, shoe, geese

d. glass, coat, committee

e. I don't know.

Look at the list of words below. Some of them are plural nouns. Some of them are singular nouns. Draw a circle around all of the plural nouns.

class

calves

men

bed

Look at the list of words below. Some of them are plural nouns. Some of them are singular nouns. Draw a circle around all of the plural nouns.

teeth

gas

chief

potatoes

Complete the following sentence using one of the answers below.

"A plural noun names_____."

Circle the letter in front of the correct answer.

a. one person, place, or thing

b. more than one person, place, or thing

c. one action

d. more than one action

e. I don't know.

Complete the following sentence using one of the answers below.

"A singular noun names_____."

Circle the letter in front of the correct answer.

a. one person, place, or thing

b. more than one person, place, or thing

c. one action

d. more than one action

e. I don't know

Test ND

Name_____

In this booklet you will be asked to answer some questions. Sometimes you will be asked to circle the correct answer to a question. Sometimes you will be asked to circle a letter in front of the correct answer. Here are some examples.

Example A

Look at the sentence below. If the sentence is correct, circle the word YES. If the sentence is not correct, circle the word NO.

All boys are also girls. YES (NO)

The sentence is not correct so the word NO is circled.

Example B

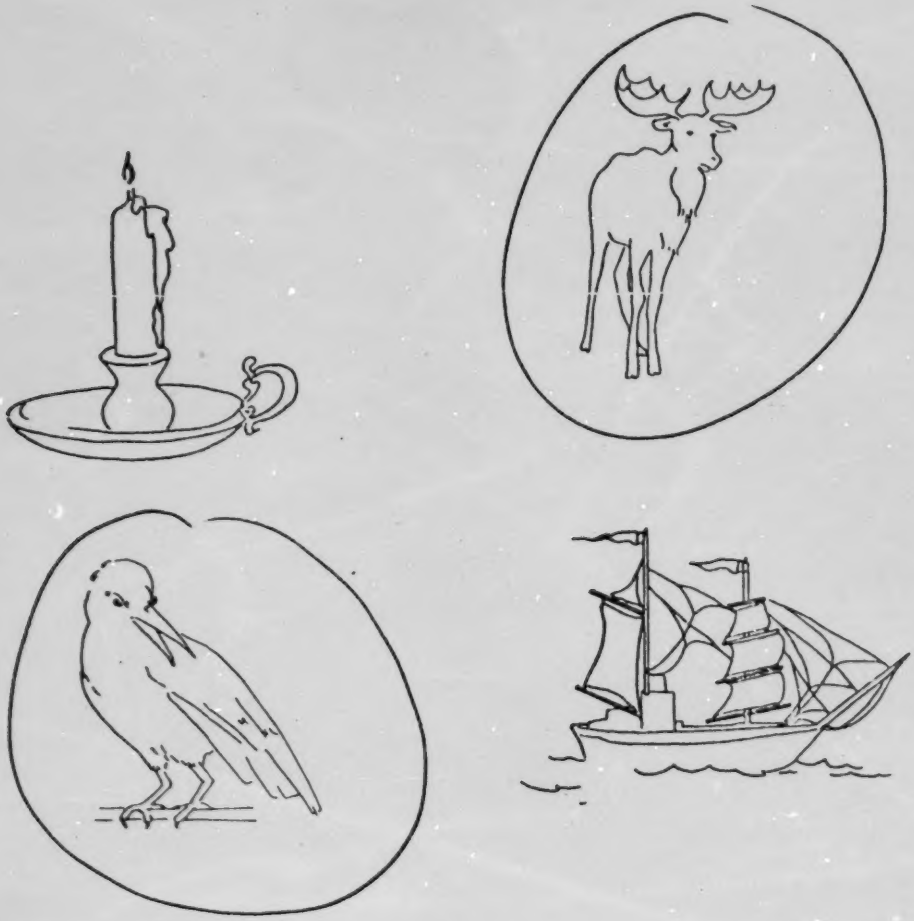
How many minutes are there in one hour? Circle the letter in front of the correct answer.

a. 10 minutes
(b.) 60 minutes
c. 90 minutes
d. 120 minutes
e. I don't know

The correct answer is 60 minutes so the letter "b" is circled.

Example C

Look at the drawings below. Draw a circle around the ones that are pictures of living things.



The moose and the bird are alive so they are circled.

General Instructions: Read each question carefully. Then choose the best answer. Make sure you answer every question. Do not skip questions. When you have finished one page, go on to the next. Do not turn back to pages you have finished. If you have any questions, raise your hand.

Directions: Look at the sentences below. Each sentence contains two nouns, a common noun and a proper noun. One of the nouns is capitalized. If the correct noun is capitalized, circle the word YES. If the correct noun is not capitalized, circle the word NO. To help you, both nouns are underlined.

1. His friends liked Tom very much. YES NO

2. The cardinals lost the Game. YES NO

3. My Boys visited disneyland. YES NO

4. Next Wednesday is my birthday. YES NO

5. Up on the Hill sat mary. YES NO

6. All students must learn French. YES NO

See the sentence below with the two words underlined.

"The cars were driven to Chicago."

In the sentence above, the word cars

(Circle the letter in front of the correct answer.)

a. names a particular thing

b. names many things

c. names a particular action

d. names many actions

e. I don't know.

See the sentence below with the two words underlined.

"The cars were driven to Chicago."

In the sentence above, the word Chicago

(Circle the letter in front of the correct answer.)

a. names a particular place

b. names many places

c. names a particular action

d. names many actions

e. I don't know.

In which group of words should every word be capitalized?

Circle the letter in front of the correct answer.

a. desks, churches, roads

b. noun, verb, adjective

c. car, book, house

d. john, denver, lake erie

e. I don't know.

In which group of words should every word be capitalized?

Circle the letter in front of the correct answer.

a. monkey, dog, nevada

b. mother, father, hope

c. africa, larry, milwaukee

d. fire, war, peace

e. I don't know.

Look at the list of nonesense words below. Pretend that they are nouns. Some are common nouns. Some are proper nouns. Draw a circle around all of the common nouns.

dax

Tas

Boz

guk

Look at the list of nonesense words below. Pretend that they are nouns. Some are common nouns. Some are proper nouns. Draw a circle around all of the common nouns.

Mun

kol

zum

Poc

Complete the following sentence using one of the answers below.

"A proper noun is_____."

Circle the letter in front of the correct answer.

a. a noun that means more than one

b. not capitalized

c. capitalized

d. the subject of a sentence

e. I don't know.

Complete the following sentence using one of the answers below.

"A common noun is_____."

Circle the letter in front of the correct answer.

a. a noun that names more than one

b. not capitalized

c. capitalized

d. the subject of a sentence

e. I don't know.

Test EE

Name_____

In this booklet you will be asked to answer some questions. Sometimes you will be asked to circle the correct answer to a question. Sometimes you will be asked to circle a letter in front of the correct answer. Here are some examples.

Example A

Look at the sentence below. If the sentence is correct, circle the word YES. If the sentence is not correct, circle the word NO.

All boys are also girls. YES (NO)

The sentence is not correct so the word NO is circled.

Example B

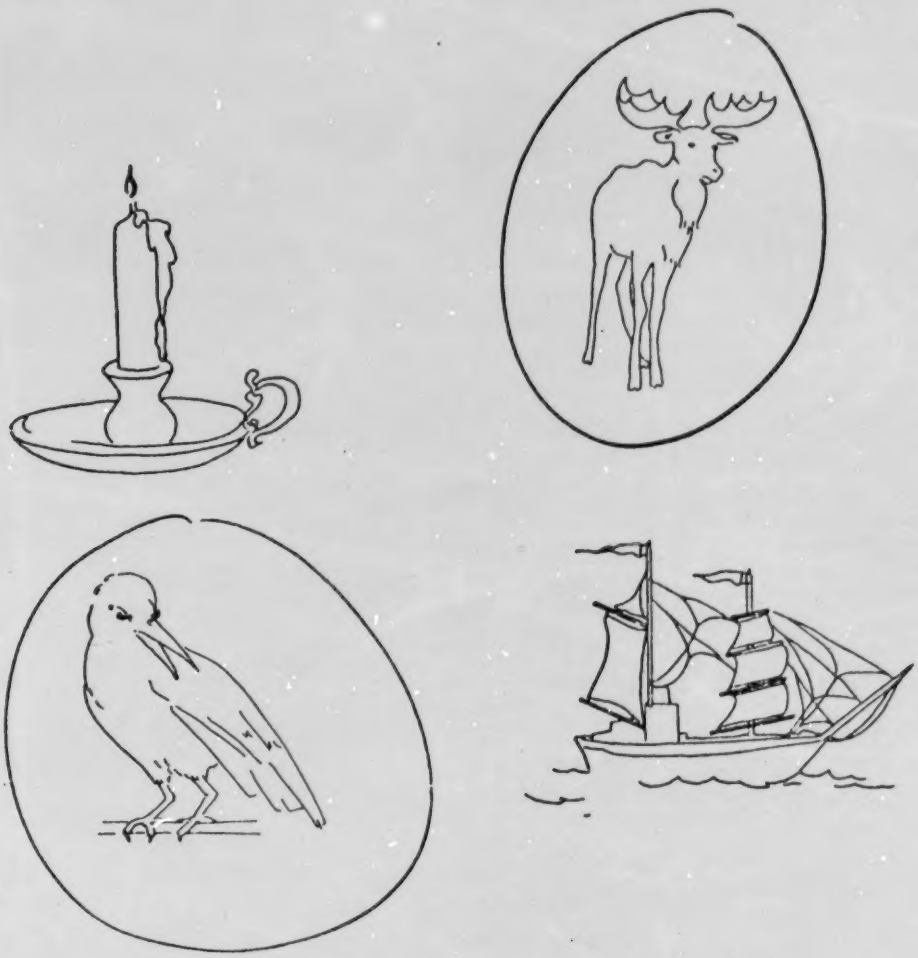
How many minutes are there in one hour? Circle the letter in front of the correct answer.

a. 10 minutes
(b.) 60 minutes
c. 90 minutes
d. 120 minutes
e. I don't know

The correct answer is 60 minutes so the letter "b" is circled.

Example C

Look at the drawings below. Draw a circle around the ones that are pictures of living things.

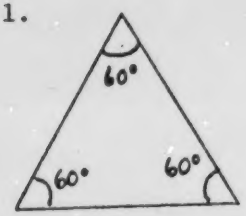


The moose and the bird are alive so they are circled.

General Instructions: Read each question carefully. Then choose the best answer. Make sure you answer every question. Do not skip questions. When you have finished one page, go on to the next. Do not turn back to pages you have finished. If you have any questions, raise your hand.

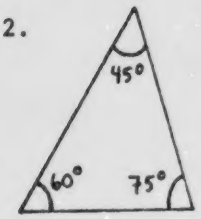
Directions: Look at the sentences and figures below. If the sentence is correct, circle the word YES. If the sentence is not correct, circle the word NO. Use only the information given. You may not measure the figures.

1.



The sides of this triangle are equal in length. YES NO

2.



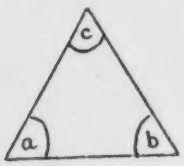
The sides of this triangle are equal in length. YES NO

3.

angle a = angle b

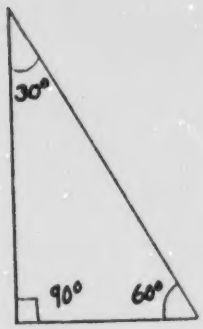
The sides of this triangle are equal in length. YES NO

4.



angle a = angle b = angle c

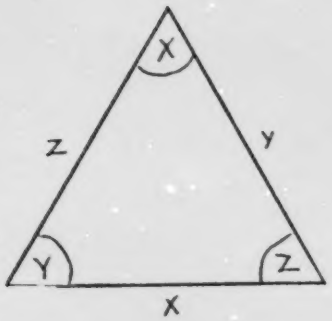
The sides of this triangle are equal in length. YES NO

5. 

The sides of this triangle are equal in length. YES NO

6.

The sides of this triangle are equal in length. YES NO



Angles X, Y, and Z have exactly the same number of degrees. Suppose that side y is 2 inches long. How long is side x? Circle the letter in front of the correct answer.

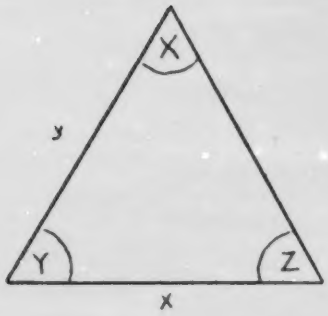
a. 1 inch

b. 2 inches

c. 3 inches

d. It is impossible to tell without measuring.

e. I don't know.



Angles X, Y, and Z each have exactly the same number of degrees. Therefore, side x is _____ side y.

Circle the letter in front of the correct answer.

a. longer than

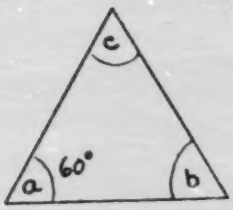
b. shorter than

c. equal to

d. It is impossible to tell without measuring.

e. I don't know.

4-



The sides of this triangle are equal in length. What size are <u>angles b</u> and <u>c</u>?

Circle the letter in front of the correct answer.

a. <u>Angle b</u> is 60° but <u>angle c</u> is smaller.

b. <u>Angle c</u> is 60° but <u>angle b</u> is smaller.

c. <u>Angle b</u> and <u>angle c</u> are both 60°.

d. It is impossible to tell.

e. I don't know.

1 inch

Look at the triangle on the left. How long is side y?

Circle the letter in front of the correct answer.

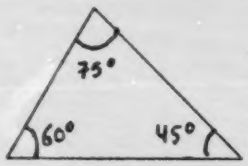
a. 1 inch

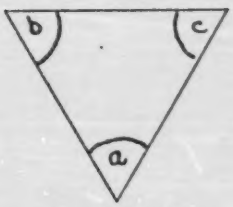
b. 2 inches

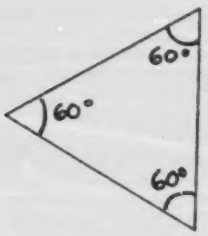
c. it is impossible to tell without measuring.

d. I don't know.

Look at the figures below. Some have three sides that are equal in length. Some do not have three sides that are equal in length. Draw a circle around all of the figures with three sides that are equal in length. Use only the information given. You may not measure.

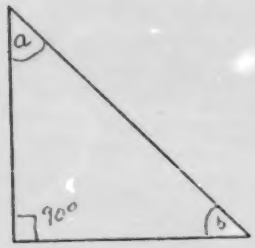




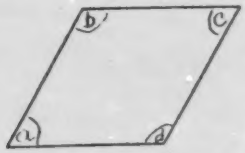


angle a = angle b = angle c

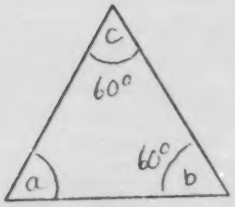
Look at the figures below. Some have three sides that are equal in length. Some do not have three sides that are equal in length. Draw a circle around all of the figures with three sides that are equal in length. Use only the information given. You may not measure.



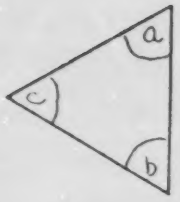
angle a = angle b



angle a = angle c
angle b = angle d



angle a = angle b



angle a = angle b
angle b = angle c

Complete the following sentence using one of the answers below.

"If _____, the sides of the triangle are equal in length."

Circle the answer in front of the correct answer.

a. the base of a triangle is equal to its height.

b. two angles of a triangle are equal in number of degrees.

c. the sum of the lengths of the sides of a triangle is an even number.

d. the three angles of a triangle are equal in number of degrees.

e. I don't know.

Complete the following sentence using one of the answers below.

"If the angles of a triangle are equal in the number of degrees, _____."

Circle the letter in front of the correct answer.

a. one side of the triangle is longer than the other two sides

b. one side of the triangle is shorter than the other two sides

c. the sides of the triangle are not equal in length

d. the sides of the triangle are of equal length

e. I don't know.

Test ED

Name_____

In this booklet you will be asked to answer some questions. Sometimes you will be asked to circle the correct answer to a question. Sometimes you will be asked to circle a letter in front of the correct answer. Here are some examples.

Example A

Look at the sentence below. If the sentence is correct, circle the word YES. If the sentence is not correct, circle the word NO.

All boys are also girls. YES (NO)

The sentence is not correct so the word NO is circled.

Example B

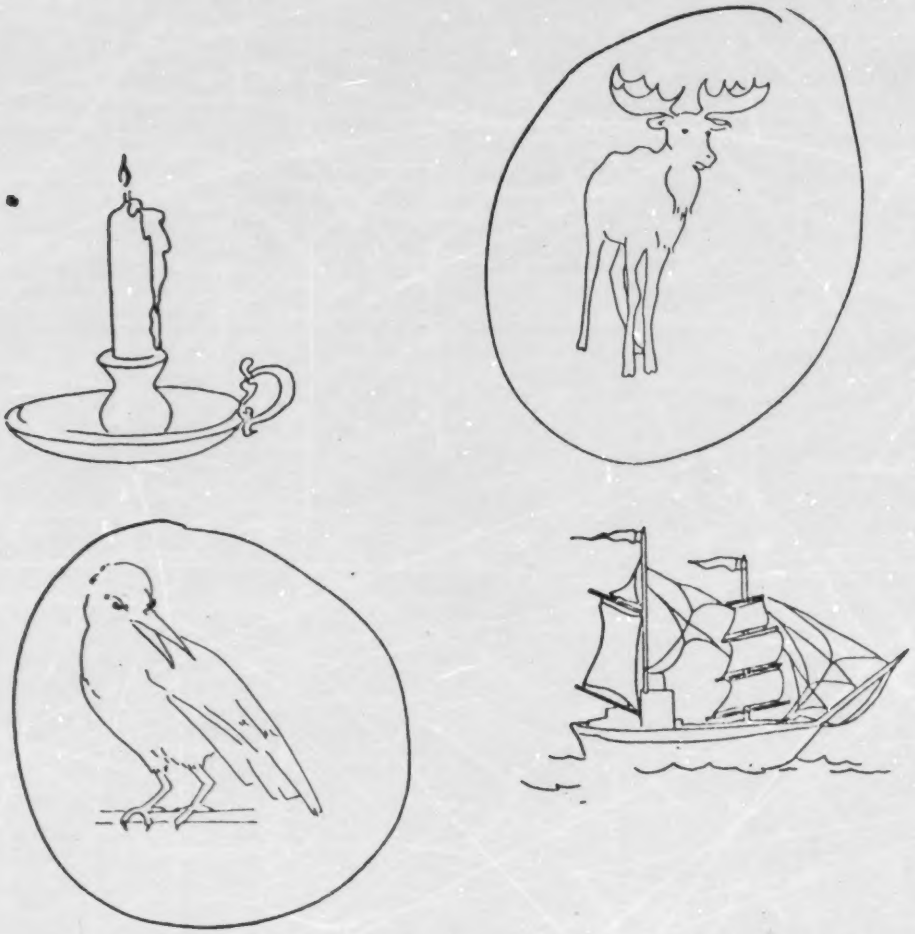
How many minutes are there in one hour? Circle the letter in front of the correct answer.

a. 10 minutes
(b.) 60 minutes
c. 90 minutes
d. 120 minutes
e. I don't know

The correct answer is 60 minutes so the letter "b" is circled.

Example C

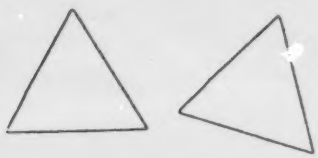
Look at the drawings below. Draw a circle around the ones that are pictures of living things.



The moose and the bird are alive so they are circled.

General Instructions: Read each question carefully. Then choose the best answer. Make sure you answer every question. Do not skip questions. When you have finished one page, go on to the next. Do not turn back to pages you have finished. If you have any questions, raise your hand.

Directions: Look at the sentences and figures below. If the sentence is correct, circle the word YES. If the sentence is not correct, circle the word NO. Use only the information given.

1. 

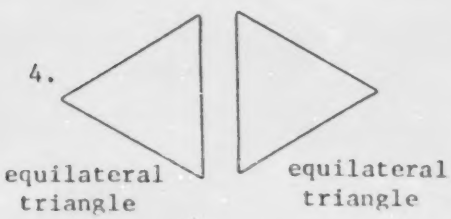
These equilateral triangles are similar in shape. YES NO

2.

These equilateral triangles are similar in shape. YES NO

3.

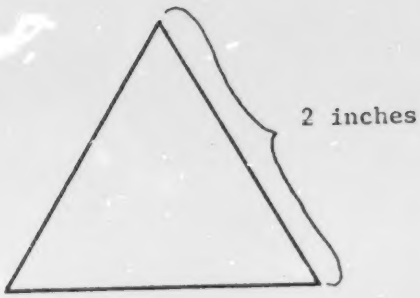
These equilateral triangles are similar in shape. YES NO

4. 

These equilateral triangles are similar in shape. YES NO

5. All of the equilateral triangles below that are similar in shape are circled. YES NO

6. All of the equilateral triangles below that are similar in shape are circled. YES NO



One side of this equilateral triangle is 2 inches long. Suppose that there was a second triangle that was similar to this one. How long would one side of the similar triangle be?

Circle the letter in front of the correct answer.

a. 1 inch

b. 2 inches

c. 3 inches

d. It is impossible to tell without measuring

e. I don't know.

Look carefully at these figures. Are they similar in shape?

Circle the letter in front of the correct answer.

a. It is impossible to tell without measuring.

b. No, only some of them are similar in shape.

c. Yes, they are all similar in shape.

d. No, they are all different sizes.

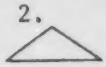
e. I don't know.

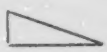
The figure below on the left is an equilateral triangle. Suppose you could blow up the small figures on the right so that they were exactly the same size as the figure on the left. Which figure on the right would then look <u>exactly</u> like the equilateral triangle on the left?

Circle the correct answer.

equilateral triangle

1.

2. 

3. 

4.

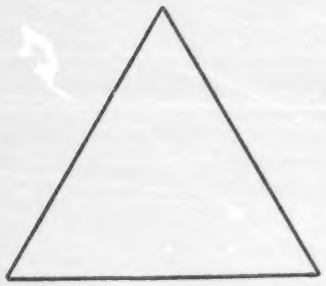
a. figure 1

b. figure 2

c. figure 3

d. figure 4

e. I don't know.



This is an equilateral triangle
Suppose that the triangle was made larger by increasing the length of each side by 1 inch. The shape of the new triangle would be _____ the drawing on the left.

Circle the letter in front of the correct answer.

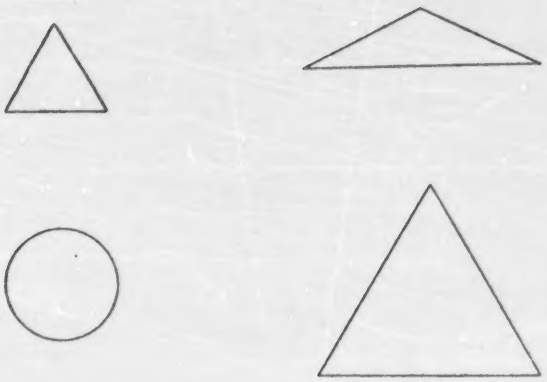
a. similar to

b. different from

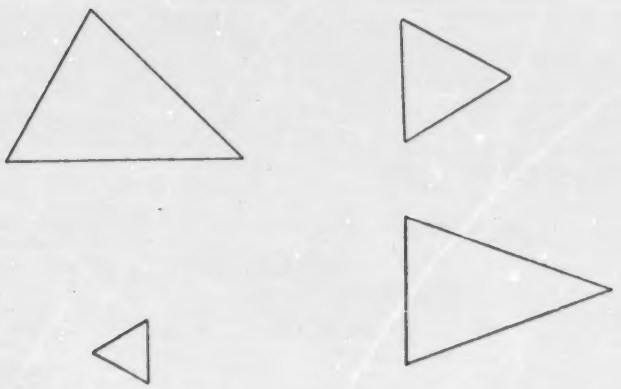
c. almost the same as

d. I don't know.

Look at the figures below. Draw a circle around the ones that are similar in shape.

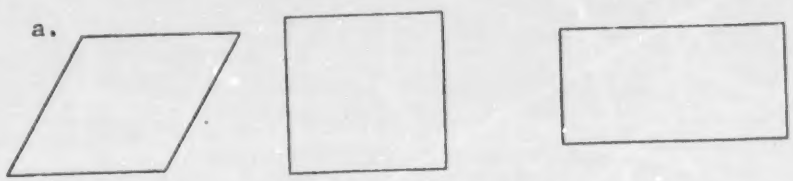


Look at the figures below. Draw a circle around the ones that are similar in shape.



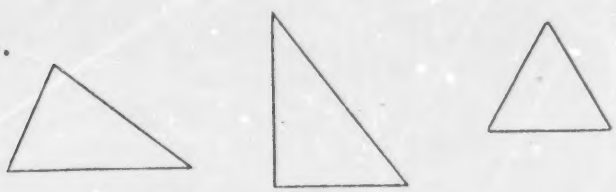
Which of the figures below are similar in shape? Circle the letter in front of the correct answer.

a.



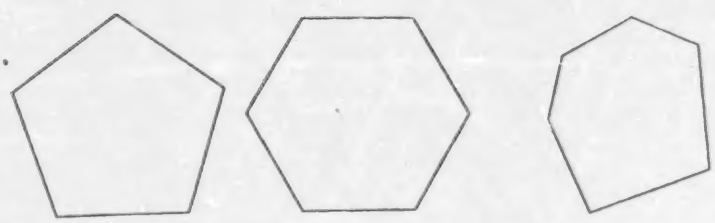
quadrilaterals

b.



triangles

c.



polygons

d.

equilateral triangles

e. I don't know.

Complete the following sentence using one of the answers below.

"All equilateral triangles are_____."

Circle the letter in front of the correct answer.

a. not identical

b. congruent

c. similar in shape

d. the same

e. I don't know.

APPENDIX F

INSTRUCTIONS TO STUDENTS

Instructions to Students

Hi.

My name is _____ and this is _____. We are working with some people at the University of Wisconsin in Madison who are very interested in finding better ways to help children learn. Today you will be able to help us by reading two lessons and then answering some questions. Now, there is no reason to be worried about what you will be doing; you are not going to be graded; the information is just for us. But please do your best, and you will help us learn how to make learning easier for other boys and girls.

We are going to pass out these brown envelopes now. In the envelopes are the lessons you will be reading. There are many different kinds of lessons. It may even seem that you are reading different kinds of lessons from everyone else. But don't worry about it because this is the way it's supposed to be. Please don't open your envelope until I tell you to.

[Pass out envelopes.]

O.K. Open your envelopes and take out the booklets inside. Don't open your booklets until I tell you to. Everyone should have a blue booklet, a green booklet, and a white booklet. Put the white booklet back in the brown envelope and put it on the floor until later.

Now take the blue booklet and put it in front of you. Push the green booklet to one side. Now fill in the cover of the blue booklet. Write or print your name (first and last), the date, your teacher's name, the school, and your grade. Then circle whether you are a girl or a boy. I'll write the date and the name of your teacher and school on the board. [Write date, teacher's name, and school on board.]

Now turn to the first page where it says word list. These are some of the words which you may find in your lessons. Because some of them may be new to you, let's take just a minute to go over them. You read aloud with me as I pronounce each word. [Read each word with kids.] There may be other words in your booklets which look new to you. If you don't know a word, raise your hand and we will help you.

Now you are just about ready to begin, but before you do, please listen carefully. Read each page in the first booklet carefully. When you finish with the booklet, push it out of your way and put the green booklet in front of you. Put your name on the green booklet and then begin reading it. Read it carefully too. When you have finished with both booklets put them together and wait quietly until everyone is finished. O.K. Now turn the page and begin. And please try to do your best.

[When everyone has finished, collect lesson booklets. Then say:]

O.K. Now take the white booklet from your envelope. Put the envelope on the floor again. Put your name on the cover of the white booklet. Now turn to the first page and follow along while I read aloud. [Read first page.] Now turn to the second page and follow along again while I read aloud. [Read second page.]

You may work on this booklet for as long as you wish. When you finish one page, go right on to the next. When you finish the whole booklet, work quietly on something else until everyone else is done. O.K. Begin.

[When all students have finished, collect test booklets, thank students; tell them they may keep the brown envelopes.]

APPENDIX G

ANALYSIS OF COVARIANCE ON KNOWLEDGE
MINUS APPLICATION DIFFERENCE SCORES

Univariate Analysis of Covariance for Knowledge Minus Application (K-A) Difference Scores

Source	df	MS	F
Sex x K-A	1	0.884	0.2637
Subject Matter x K-A	1	33.050	9.8598**
Type (easy-difficult) x K-A	1	11.410	3.4039*
Training x K-A	1	1.960	0.5847
Mode of Presentation x K-A	2	3.592	1.0716
Sex x Subject Matter x K-A	1	6.323	1.8863
Sex x Type x K-A	1	11.070	3.3025*
Sex x Training x K-A	1	6.716	2.0036
Sex x Mode of Presentation x K-A	2	5.989	1.7867
Subject Matter x Type x K-A	1	2.600	0.7756
Subject Matter x Training x K-A	1	3.070	0.9159
Subject Matter x Mode x K-A	2	0.590	0.1760
Type x Training x K-A	1	0.024	0.0071
Type x Mode x K-A	2	2.779	0.8291
Training x Mode x K-A	2	7.613	2.2712
Sex x Subject Matter x Type x K-A	1	8.493	2.5337
Sex x Subject Matter x Training x K-A	1	10.220	3.0489*
Sex x Subject Matter x Mode x K-A	2	12.020	3.5859**
Sex x Type x Training x K-A	1	0.012	0.0036
Sex x Type x Mode x K-A	2	1.974	0.5889
Sex x Training x Mode x K-A	2	2.115	0.6310
Subject Matter x Type x Training x K-A	1	4.124	1.2303
Subject Matter x Type x Mode x K-A	2	2.348	0.7005
Subject Matter x Training x Mode x K-A	2	2.882	0.8598
Type x Training x Mode x K-A	2	4.700	1.4021
Regression due to higher order interactions	11	4.382	1.3072
Error	110	3.352	

** $p < .05$

* $p < .10$

A paired t test carried out on the difference between knowledge and application scores for each subject revealed that the two groups of scores were significantly different (t=8.4704, df=158, p<.05).

APPENDIX H

RAW SCORE MEANS, STANDARD DEVIATIONS, AND CELL SIZES

Means, Standard Deviations, and Cell Sizes for Knowledge Items

Language Arts Principles

		Mode of Presentation					
		Set		One Example		Placebo	
		Male	Female	Male	Female	Male	Female
Training on Subconcepts	Easy Principle	5.333 (2.082) n=3	7.400 (0.894) n=5	7.000 (1.000) n=3	7.250 (0.957) n=4	8.000 (0.000) n=3	6.000 (0.000) n=2
	Difficult Principle	7.500 (1.000) n=4	5.667 (2.517) n=3	7.333 (1.155) n=3	8.000 (0.000) n=4	6.667 (0.577) n=3	7.333 (0.577) n=3
No Training on Subconcepts	Easy Principle	6.333 (2.082) n=3	7.667 (0.577) n=3	4.000 (1.732) n=3	8.000 (0.000) n=3	6.667 (1.528) n=3	6.650 (1.000) n=4
	Difficult Principle	7.000 (1.000) n=3	6.500 (1.000) n=4	7.667 (0.577) n=3	7.000 (1.732) n=3	5.667 (2.309) n=3	5.750 (2.630) n=4

Means, Standard Deviations, and Cell Sizes for Knowledge Items

Mathematics Principles

		Mode of Presentation					
		Set		One Example		Placebo	
		Male	Female	Male	Female	Male	Female
Training on Subconcepts	Easy Principle	7.333 (0.577) n=3	7.000 (0.816) n=4	7.250 (0.957) n=4	6.333 (0.577) n=3	7.250 (0.500) n=4	6.333 (2.082) n=3
	Difficult Principle	7.500 (1.000) n=4	6.000 (1.000) n=3	7.000 (1.000) n=3	4.250 (1.500) n=4	4.667 (0.577) n=3	6.000 (1.732) n=3
No Training on Subconcepts	Easy Principle	6.500 (1.000) n=4	7.333 (0.577) n=3	8.000 (0.000) n=3	7.000 (0.000) n=3	6.000 (0.000) n=3	7.333 (0.577) n=3
	Difficult Principle	6.500 (1.732) n=4	6.250 (1.708) n=4	6.000 (2.646) n=3	7.667 (0.577) n=3	5.000 (2.000) n=3	5.000 (1.000) n=3

Means, Standard Deviations, and Cell Sizes for Application Items

Language Arts Principles

		Mode of Presentation					
		Set		One Example		Placebo	
		Male	Female	Male	Female	Male	Female
Training on Subconcepts	Easy Principle	1.667 (0.577) n=3	7.000 (0.707) n=5	6.000 (2.646) n=3	6.000 (2.708) n=4	6.667 (0.577) n=3	0.500 (0.707) n=2
	Difficult Principle	6.500 (1.291) n=4	3.000 (2.000) n=3	7.333 (0.577) n=3	3.500 (1.000) n=4	4.667 (2.887) n=3	5.000 (2.646) n=3
No Training on Subconcepts	Easy Principle	3.000 (2.646) n=3	7.333 (1.155) n=3	7.333 (1.155) n=3	7.000 (1.000) n=3	4.333 (3.786) n=3	4.750 (2.222) n=4
	Difficult Principle	5.000 (2.646) n=3	5.750 (1.500) n=4	6.667 (0.577) n=3	5.000 (2.646) n=3	5.333 (2.517) n=3	4.250 (2.062) n=4

Means, Standard Deviations, and Cell Sizes for Application Items

Mathematics Principles

		Mode of Presentation					
		Set		One Example		Placebo	
		Male	Female	Male	Female	Male	Female
Training on Subconcepts	Easy Principle	5.667 (2.082) n=3	5.750 (2.217) n=4	5.750 (2.630) n=4	6.667 (1.528) n=3	5.000 (2.309) n=4	4.000 (1.000) n=3
	Difficult Principle	7.250 (0.957) n=4	5.667 (1.528) n=3	5.333 (1.528) n=3	5.500 (1.291) n=4	4.667 (1.155) n=3	4.667 (2.082) n=3
No Training on Subconcepts	Easy Principle	6.750 (2.500) n=4	7.333 (1.155) n=3	5.333 (1.155) n=3	4.667 (3.214) n=3	4.000 (2.646) n=3	7.000 (1.000) n=3
	Difficult Principle	5.500 (1.000) n=4	6.000 (2.450) n=4	5.333 (2.082) n=3	6.667 (1.528) n=3	4.000 (1.000) n=3	4.667 (1.528) n=3

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